ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

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MANAGEMENT PROGRAM UNIT

FLORISTIC COMPOSITION AND DIVERSITY OF HERBACEOUS FLOWERING PLANTS IN MENAGESHA SUBA STATE FOREST, OROMIA REGION, ETHIOPIA

By

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A THESIS SUBMITTED TO SCHOOL OF GRADUATE STUDIES OF ADDIS ABABA UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN PLANT BIOLOGY AND BIODIVERSITY MANAGEMENT

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AAU	Addis Ababa University
BI	Birdlife International
EFAP	Ethiopian Forestry Action Plan
EPA	Environmental Protection Authority
ETH	National Herbarium of Ethiopia
FAO	Food and Agriculture Organization
FEE	Flora of Ethiopia and Eritrea
FRD	Federal Research Division
GBG	Gullele Botanical Garden
GEF	Global Environmental Facility
GOs	Governmental Organization
IBC	Institute of Biodiversity Conservation
IUCN	International Union for the Conservation of
MOA	Ministry of Agriculture
MOARD	Ministry of Agriculture and Rural Development
	Nature and Natural Resources
NBSAP	National Biodiversity Strategy and Action plan
NGOs	Non-Governmental Organizations
PCC	Population Census Commission
UNEP	United Nations Environment Programme
USAID	United States of America International Development
WBISPP	Woody Biomass Inventory and Strategic Planning Project
WWF	World Wildlife Fund

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ABSTRACT: *The current study was conducted on the dry evergreen montane forest known as Menagesha Suba State Forest, which is situated 30 km away in the south west of Addis Ababa in Oromia National Regional State. The study mainly focuses on the assessment of the diversity of herbaceous flowering plants in the Forest under study. Seventy five quadrats/plots of 20 m x 20 m (400 m²) were laid down along the transect line and the required vegetation data were collected and analyzed. A total of 128 species representing 102 genera and 44 families of herbaceous flowering plants were recorded from the Forest. Asteraceae is the highest in species diversity and richness (24%) followed by Poaceae (8.6%) and Apiaceae (4.7%) respectively. Of the 128 species of herbaceous flowering plants about 14 (11%) are endemic to Ethiopia of which four of them are threatened as vulnerable and endangered. Vegetation classification was done with PC-ORD computer software package which produced five plant communities.*

Key words/Phrases: *Herbaceous Flowering Plant, Menagesha Suba State Forest, diversity*

1. INTRODUCTION

1.1 General Background

Tropical forests are the storehouses of biodiversity and constitute the most diverse plant communities on earth (Brady, 1994; Supriya and Yadava, 2006). According to Wilson (1988), over half of the global number of species, which is estimated to be in millions, is found to be in tropical forests. Tropical forests account for 52% of the total forest area of the world, of which 42% is dry forest, 33% is moist forest and 25% is wet and rainforest (Murphy and Lugo, 1986). Dry forests are next to rainforests in ecological complexity, which arises from the strong seasonal and inter-annual variability in rainfall, which permits the occurrence of very diverse flora and fauna (Khurana and Singh, 2001).) The largest proportion of tropical dry forests is found in Africa, where it accounts for 70–80% of the forested area (Demel Teketay, 1996) and Africa's rich biodiversity is estimated to comprise about 25% of global biodiversity in terms of ecosystems, species composition and genetic variety (Mugabe, 1998).

The Ethiopian highlands contribute to more than 50% of the land area with Afromontane vegetation of which dry montane forests form the largest part (Tamirat Bekele, 1994). Ethiopia is biologically and culturally diverse, and it is among the four most diverse countries in Africa for endemic vertebrate and vascular plants (Alemayehu Mengistu, 2003). The country has also several major ecological systems that support large and highly varied genetic resources along with its extremely variable agro-climatic conditions. Ethiopia has a great topographical diversity with high, rugged mountains, flat topped plateaus, deep gorges, incised river valleys and rolling plains. The altitudinal variation ranges from 110 m below sea level in some areas of Kobar Sink, to 4,620 m a.s.l. at Ras Dejen [Dashen] (FAO, 1996). The country also consists of two major high plateau regions separated by the Rift Valley and bounded on all sides by lowlands (Friis 1992; Tamrat Bekele 1993). The diversity of Ethiopia's terrain determines regional variations in climate, natural vegetation, soil composition, and settlement patterns (FRD, 2005).

The country is an important regional center for biological diversity due to its wide ranges of altitude, its great geographical diversity with high and rugged mountains, flat-topped plateaus and deep gorges, incised river valleys and rolling plains (Ensermu Kelbessa *et al.*, 1992; Zerihun Woldu, 1999). These helped the emergence of wide ranges of habitats that are suitable for the evolution and survival of various plant and animal species. Furthermore, Brenan (1987) stated that the varied topography, the rift valley and the surrounding lowlands and diverse climatic conditions have led to the emergence of a range of habitats which are suitable for evolution and survival of various plant and animal species, and that they have given the country a wide spectrum of habitats and a large number of endemic plants and animals.

As various sources indicated, about 35–40 % of the country's land area was once covered with high forests at the turn of the 19 century (Breitenbach, 1961). A substantial proportion of the Ethiopian highlands were once believed to have been covered by forests having wide coverage than at present, but have gradually been cleared (Friis, 1992). It was remarked that the occurrence of isolated mature trees in farmlands and the patches of forests that are seen around church-yards and religious burial grounds indicate the presence of vast expanse of forests earlier (Tamrat Bekele1, 993). However, the loss of forest cover and biodiversity due to human-induced activities is a growing concern in many parts of the world including Ethiopia (Feyera Senbeta and Demel Teketay, 2003) and historical documentation indicated that Ethiopia had experienced substantial deforestation, soil degradation and an increase in the area of bare land over the years. The need for fuelwood, arable land and grazing areas have been indicated as the main causes of forest degradation; frequently leading to loss of forest cover and biodiversity, erosion, desertification and reduced water resources (Ensermu Kelbessa and Teshome Soromessa, 2008).

Little of the natural vegetation of the highlands remains today, except for the few forest patches in the south and southwestern parts of the country. The influence of humans and domestic animals has profoundly altered both the vegetation and the landscape. Ecological degradation, including deforestation and erosion, is widespread, particularly in the northern and central highlands of the country. Though not as severely degraded, the southern parts of the highlands are being increasingly affected (WWF, 2001). The highlands, which are defined as land areas above 1500 m a.s.l., with the associated valleys, constitute about 44% of the country (EFAP, 1993). The highlands of Ethiopia, in contrast to most mountain systems outside Africa, are very suitable for human inhabitation. This population pressure on the highlands accompanied by sedentary agriculture, extensive cattle herding activities and socio-political instability, has resulted in heavy deforestation, forest fragmentation, and loss of biodiversity and impoverishment of ecosystems in general (Eshetu Yirdaw, 2002).

Generally, over the last 3000 years, there has been progressive deforestation, which has accelerated tremendously during the last century (UNEP, 1983). As a result of Rapid population growth, extensive forest clearing for cultivation, overgrazing, movement of political centers, and exploitation of forests for fuelwood and construction materials without replanting reduced Ethiopia's forest area to 16 percent in the 1950s and to 3.1 percent by 198 (Badege Bishaw, 1993).

1.2 Statement of the Problem

Regardless of the fact that, Menagesha Suba State Forest is considered the oldest park in Africa, it is also amongst the few remaining patches of dry evergreen afromontane forest in the central highlands of Ethiopia. According to MOARD (2002), the First National Policy on Forests for Ethiopia was developed by Emperor Menelik II in the late 1890s. The emperor set aside State Forest Reserves, including Menagesha State Forest for which guards were assigned to protect the Forest, and boundary demarcation was established. The current study area was once studied by Sebsebe Demissew (1980). The study of the later author provides detailed information on comparison of the study Forest with other forests in Ethiopia in between the year 1980 and 2006, recommended that better attention be given towards the management and rational utilization of the forest resources of the area. Most of the scholars which have studied the vegetation of Ethiopia gave emphasis to the economic value of the forest resource rather than the ecological, cultural, and other aspects. As a result, trees and shrubs have been considered economically more important than herbaceous components with regard to timber, fuelwood, gum and resin production for livelihood of the people, especially in Ethiopia where poverty is the major problem. On the contrary, the ecological, medicinal, and wild relatives of many cereal and pulse crops (a store house of genetic pool) are herbaceous plants which may not be underestimated.

The present study focuses on the assessment of floristic composition of herbaceous flowering plants of the Forest due to their vital role in economic, ecological, medicinal, cultural and other uses/ values within the society at national, regional and local level.

1.3 Objectives

1.3.1 General Objective

→ To study the floristic composition and species diversity of herbaceous flowering plants in Menagesha Suba State Forest and to classify the herbaceous vegetation into plant community types.

1.3.2 Specific Objectives

- ✓ To assess the diversity of herbaceous flowering plants and determine the herbaceous plant community types in the study area;
- ✓ To make phytogeographical comparisons of the Forest with any other related dry evergreen afromontane forests in the country with regard to herbaceous flowering plants;
- ✓ To generate baseline information that would help in the future management and conservation of the Forest.

2. LITERATURE REVIEW

2.1 Vegetation of Ethiopia

Vegetation is an assemblage of plants growing together in a particular area, or in other words the collective plant cover of an area (Jennings *et al*., 2003). Several native and foreign scholars have attempted to study the vegetation resources of Ethiopia, comprising forests, woodlands and bushlands (Teshome Soromessa *et al*, 2004). From the beginning of 19th C to mid 20th C foreign travelers undertook most of the vegetation studies, identifications and descriptions in Ethiopia. It is the spatial pattern of growth forms in a plant community, especially in relation to their height, abundance or coverage within the individual layer (Jennings *et al*., 2003). Friis (1992) defined forest as "a continuous stand of trees, which may attain from 10 m to 50 m or more, with crowns touching or intermingling and often interlaced with lianas". The canopy usually consists of several distinct layers. The vegetation cover of a given area has a definite structure and composition developed from long-term interaction of biotic and abiotic factors.

Ethiopia is endowed with diverse ecosystems in which diverse flora and fauna as well as microbial resources are found. The major ecosystems of the country encompass: Afroalpine and subafroalpine, dry evergreen montane forest and scrub, moist montane forest, montane grassland, *Acacia-Comiphora* woodland, *Combretum-Terminalia* woodland, Lowland humid forest, Desert and semidesert, wetland, and Aquatic ecosystems (Friis, 1992; Sebsebe Demissew *et al. 1996*, Friis and Sebsebe Demissew, 2001). According to EFAP (1994), there are 92 high forests in Ethiopia out of which 56 are dry evergreen montane forests, 29 moist montane forest, 5 transitional dry moist evergreen montane forests and 2 lowland semi-evergreen forests.

Ethiopia is a tropical country with varied macro- and micro-climatic conditions that have contributed to the formation of diverse ecosystems inhabited with a great diversity of life forms of both animals and plants (FAO, 1996). Ethiopia, being near the equator and with an extensive altitude range, has a wide range of climatic features suitable for different agricultural production systems. Climatic heterogeneity is a general characteristic of the country and these climatic elements include precipitation, temperature, humidity, sunshine, wind, which are affected by geographic location and altitude. Temperature and rainfall are the most important climatic factors for agricultural production in Ethiopia. Altitude is a factor that determines the distribution of climatic factors and land suitability; this influences the crops to be grown, rate of crop growth, natural vegetation types and their species diversity (Alemayehu Mengistu, 2003). The most important influential environmental factors affecting vegetation distribution and patterns in Ethiopia are altitude, climate (precipitation and temperature), and soil type and the interaction of these factors. The rainfall pattern in Ethiopia is influenced by two rain-bearing wind systems, one bringing the monsoonal wind systems from the South Atlantic and the Indian Ocean and the winds from the Arabian Sea. The two wind systems alternate, causing different rainfall regimes in different parts of the country (IBC, 2005).

2.1.1 The Status of Biodiversity in Ethiopia

The flora of Ethiopia is very heterogeneous and has a rich endemic element. It is estimated to contain about 6000 species of higher plants, of which about 10% are endemic. Endemism is particularly high in the high mountains and in the Ogaden and Borana lowlands. There is also great diversity of fauna in Ethiopia, owing to the diversity in climate, vegetation, and terrain. It is estimated that there are 281 species of mammals, 861 species of birds of which 29 species of mammals and 15 species of birds are endemic. There are about 201 species of reptiles of which 87 snakes, 101 lizards, one species of crocodile, and 13 species of tortoises and turtles and 9 of them are endemic and a total of 63 species of amphibians have also been recorded in Ethiopia of these 23 species are listed as endemic. Ethiopia has a very high genetic diversity four of the worlds widely grown food crops like wheat, barley, sorghum, peas, and industrial crops like linseed, castor bean and cotton and also cash crops like coffee. Ethiopians also use more than 887 medicinal plants for their health care and plenty of indigenous knowledge related with the extraction and application of these plant resources which are the baseline for the modern pharmaceutical technologies (Panos Ethiopia, 2010). The contemporary status of biodiversity resource in Ethiopia is more illustrated in (table 2).

The biogeography – and biodiversity – of the country is characterized by two dominant geographical features. The Ogaden, one of the three centers of endemism of the ancient arid Horn of Africa falls within Ethiopia. The highland plateaus are the second biogeographical feature. Although they are relatively young in evolutionary terms and they have experienced relative climatic instability over the past 1.5 million years (both in contrast to the arid Horn), highland isolation has resulted in significant endemism. Whilst the arid Horn and young highlands are relatively impoverished in species number (compared to other continents), the levels of endemism are high. The biodiversity of Ethiopia (and the extent to which it is currently threatened) has recently received appropriate recognition. The majority of the country now falls into one of two Biodiversity Hotspots. Thus, the Ethiopian highlands comprise over 50% of the Eastern Afromontane Hotspot and over 40% of the Horn of Africa Hotspot falls within Ethiopia. However, the areas are among the most threatened Hotspots in the world. An estimated 97% of the natural vegetation of Ethiopian Highlands has been lost, with humans having significant impacts on an estimated 95% of the natural vegetation in the Horn of Africa (GEF, 2008).

2.1.2 Dry Evergreen Montane Forests

Mountains cover about 22% of the terrestrial land area of the Globe, hold about 12% of the global human population, and about 50% of the human population depends on freshwater resources from mountains. They are important sources of biodiversity and livelihoods and also important regulators of climate. However, mountains have been characterized as one of the world's most vulnerable bio-geographic areas susceptible to land degradation, that has suffered from loss of indigenous culture and traditions that embody thousands of years of lessons learned about sustainable mountain environment management (Gete Zeleke, 2010). As indicated by Richter (2008), nearly all of the world´s mountain chains harbour montane forests. The forested mountains differ considerably in their vegetation nature and three main groups may be distinguished: 1) Extratropical mountains, with mixed and pure coniferous forests in the northern and deciduous forests in the southern hemisphere; 2) Subtropical mountains, with evergreen as well as deciduous broadleaved forests in the more humid and coniferous woodlands in the drier ecozones; and 3) Tropical mountains, with evergreen and semi-deciduous forests. In terms of phytogeography, temperate floristic elements become increasingly important towards mountains of the outer tropics. Species richness is much higher in humid tropical mountains than in dry ones. In terms of biodiversity, tropical mountain forests are one of the world's main hotspots. The latest map of the global species diversity of vascular plants (Barthlott *et al.*, 2005; cited in Richter, 2008) emphasizes tropical mountain areas as the world´s most important diversity hotspots.

The tropical dry evergreen forests are among the least known and unique vegetation types confined to a few localities in the world. Dry evergreen montane forests have also been reported elsewhere in the tropics particularly in Africa, they are confined to the Ethiopian highlands, Tanzania, and Zambia (Parthasarathy *et al.*, 2008). Typical dry evergreen montane forests in Ethiopia are situated on highlands and mountains occurring at altitudinal ranges of 1,500 to 3,200 m. a. s. l. The forests in this ecosystem have greatly diminished due to expansion of agriculture and other interference by people and domestic animals and have been replaced by bushland and scrub in most areas. Dry evergreen montane forest is multi-storeyed (i.e. the vegetation makes much layers). The top storey consists of the taller trees known as "emergent" because they project above the lower layers. Below the emergent there is a layer of shorter trees of various heights forming a more or less continuous canopy. Still lower is a stratum of short trees and large shrubs, much less dense than the second stratum. Finally, there is the lowest stratum of shrubs, suffrutescents, and herbs. Epiphytes, lianas and semi-parasites are common (Zerihun Woldu, 1999). This vegetation is characterized by *Olea europaea* subsp. *cuspidata*, *Juniperus procera*, *Prunus africana*, *Celtis africana*, *Euphorbia ampliphylla*, *Carissa spinarum*, *Euclea divinorum*, *Rosa abyssinca*, *Pittosporum viridiflorum*, *Ekebergia capensis*, etc. There are mixed provenances of *J. procerea*, some of which can get very big while others remain small. In moister areas, this vegetation type includes *Podocarpus falcatus* and is associated with stands of highland Bamboo (*Arundinaria alpina*). The patches of grassland are rich in species including many legumes. The most important grass genera are *Hyparrhenia*, *Eragrostis*, *Panicum*, *Sporobolus* and *Pennisetum* while the most important herbaceous legumes are species of *Trifolium*, *Eriosema*, *Indigofera*, *Tephrosia* and *Crotalaria*. These include a large number of endemic species. Climbers include *Smilax aspera*, *Rubia cordifolia*, *Urera hypselodendron*, *Embelia schimperi*, *Jasminum abyssinicum*, various species in the Cucurbitaceae, and other families that often join this element of the vegetation (IBC, 2009).

Typical dry evergreen montane forests in Ethiopia are found on highlands and mountain chains and examples with the following locations: Chilimo Forest (38° 10' E and 9° 05' N), 2400 ha; Menagesha Forest (38° 35' E and 9° 00' N), 2720 ha; Wof-Washa Forest (39° 45' E and 9° 35' N), 3600 ha, Sanka Meda Forest (39^{0} 58’ 52”E and 8^{0} 22' 09”N), 480 ha; and the Gedo Forest ($37^{0,}$’25’ E and 9^{0} 02’ N) 67,472.5 ha; (Sebsebe Demissew, 1988; Tamrat Bekele 1994, Shambel Bantewalu, 2010 and Birhanu Kebede, 2010) and others. It is inhabited by the majority of the Ethiopian population and represents a zone of sedentary cereal-based mixed agriculture for centuries. This type of forest develops in areas of relatively high humidity, but not much rain, and where there is a prolonged dry season. Ethiopian Dry Evergreen Montane Forests are distributed in central (east, west and north Shewa, Arsi and Gurage zones), northern (east and west Gojam, north and south Gonder, south and north Wello, Agew Awi, and south, east and west Tigray zones) eastern (east and west Hararghe, Afar and Dire Dawa zones) and southern (Bale, Borona, and South and north Omo zones) parts of Ethiopia. They are limited to five national regions in the country namely, Amhara, Oromia, Tigray, SNNP, and Afar regions (IBC, 2007).

2.1.3 Threats on Biodiversity in Ethiopia

Ethiopia is one of the most diverse and important sources of biodiversity in the world for wild, cultivated, or domestic organisms due to its high number of endemic species, the genetic diversity of several cultivated crops, and the variety of breeds of cattle, goats, sheep, camels, horses, and donkeys. However, the trees and forests of Ethiopia are under tremendous pressure because of the drastic decline in mature forest cover and the continual pressures of population increase, rudimentary farming techniques, land use competition, land tenure, and forest degradation and conversion, and the status of the forest resources should be considered at risk (USAID, 2008). In addition, due to extensive human influence on the biodiversity resource, the future fate of Ethiopia is under question with the current rapid rate of population growth and global climate change. Threats to Ethiopia's biodiversity, tropical forests, and resource base can be broadly linked to the following categories: limited governmental, institutional, and legal capacity; population growth; land degradation; weak management of protected areas; and deforestation (USAID, 2008).

Tropical deforestation is considered the second largest source of anthropogenic greenhouse gas emissions (Rademaekers *et al.*, 2010) and is expected to remain a major emission source for the foreseeable future (MEA, 2005). Despite policy efforts on reducing deforestation, around 13 million hectares of forests continue to be lost every year (FAO, 2006). The reduction of greenhouse gas emissions from tropical deforestation is now recognized as an essential component of international efforts to mitigate climate change. Africa's 635 million hectares of forests account for 21.4% of its land area and 16% of the global forest area. In total, some 23 million hectares of this forest disappeared in the 1980s while another 20 million hectares gave way for other land uses in the 1990s. Recent estimations show that another 4 million hectares of forest were deforested between 2000 and 2005, which is equivalent to one-third of the total deforested area on a global level. Yet, there are some indications that net loss of forest area has slowed down and that the areas of forest designated for conservation of biological diversity has increased slightly. However, it is a fact that the permanent, rapid loss of forest area occurring in Africa is representing the highest percentage of any region during the 1980s, 1990s and early 2000s (FAO, 2006).

The Ethiopian biodiversity is being increasingly threatened and reduced, making Ethiopia one of the most degraded biodiversity hotspots in the world and the threats are multiple interconnected (Lightbourne, 2006). Human population densities have increased considerably in recent times due to various reasons, at a rate faster than the ability of the land to support. As a result, in order to maintain basic living standards, natural resources have been used up faster than can be naturally replenished or before new sources have been found. The consequences of this unplanned and unsustainable use of natural resources, together with alterations to the climate and natural ecological processes, have been extensive land degradation, and loss of habitat together with the loss of valuable genetic reserves. It is therefore now imperative that the degradation processes be halted, and even reserved, in order to ensure the sustainable utilization of the numerous ecosystems for the Ethiopian people, both present and future generations (Teshome Ashine, 1990).

Land degradation, defined as a temporary or permanent decline in the productive capacity of the land or in its potential for environmental management, has been a significant cause of the low yield of crops and livestock in Ethiopia (Poulos Dubale, 2001). Land degradation is threatening biological resources and agricultural productivity, the mainstay of the economy in Ethiopia. Deforestation and subsequent cultivation of the tropical dry Afromontane forest has also endangered the native forest biodiversity, not only through the direct loss of habitat but also by deteriorating the soil seed banks (Mulugeta Lemenih, 2004). The greatest threat to biodiversity is the loss of habitat as human beings develop land for agriculture, grazing livestock, draining wetlands and unwise use of pesticides. As human populations increase their encroachment on natural habitats, they are having a detrimental effect on the very ecosystems on which they depend. In Ethiopia, the most drastic damage has occurred in the natural high altitude forests and their biological resources that once covered more than forty-two million hectares (Booth, 2004). There has been progressive deforestation in Ethiopia over the last 5000 years (since the beginning of agriculture in the country), which has accelerated tremendously during the last century as the country's population has grown.

As a result of population increase, increased crop cultivation in marginal areas and increased livestock grazing pressure have also contributed to increased deforestation and soil erosion in the central highlands (Badege Bishaw, 2001). In the forested areas of the south and southwest, deforestation is occurring at a sustained rate with major forestry threats including resettlement, commercial farming and fire. In the eastern and southern lowlands, commercial agricultural investments, rangeland enclosures, (re)-settlement schemes, charcoal production and the relentless expansion of very aggressive invasive alien species are having a profound and detrimental effect on the natural resources availability, the traditional rangeland management systems and institutions in place and ultimately the livestock based pastoralist livelihoods of the Afar, Somali and Borana people. In this respect, the current agro-fuel investment scramble taking place in many lowland areas does not bode well for the future and stability of pastoralist livelihoods in Ethiopia. Other major ecosystems in Ethiopia (wetlands and afro-alpine areas) are also increasingly being threatened and degraded (McKee, 2007).

The forest cover of Ethiopia has suffered severe deforestation and degradation through heavy exploitation resulting from an escalating demand for fuelwood and land for cropping and grazing (Lisanework Nigatu and Mesfin Tadesse, 1989). Because of the nutrient content of ash and mobilization of some soil nutrients, crop yields increase after slash-and-burn forest clearing (Ehui and Hertel, 1992). This may motivate farmers unable to purchase the necessary agricultural inputs to convert forest land to agriculture every year. As a result of such activities in much of Ethiopia, deforestation has generated both an energy crisis and fears of desertification on a national level (Roundy, 1985).

The causes for forest decline in south-central Ethiopia is considered as the combined result of socio-political changes, economic activities, population growth, cultural patterns and agricultural developments. Among other events that may alter the trajectory of change is the introduction and prioritization of certain crops. Many authors have shown how the emergence of coffee, haricot beans and chat/khat intensified changes by promoting economic activities, establishment of new markets, immigration and settlement, all of which factors have contributed ultimately to forest decline (Gessesse Dessie, 2007).

2.1.4 Conservation Issues

Menagesha Suba State Forest has a long history of resource exploitation and reforestation due to its close proximity to Addis Ababa and other small towns such as Sebeta and Holleta. As early as the fifteenth century the forest was degraded and then replanted with *Juniperus procera* on the orders of Emperor Zera Yacob. In the 1900s, large scale removal of wood for fuel and construction was noted, with strict protection was put in place and had been maintained until recently. Reforestation started as early as 1949, when logging operations were still in full swing. Since 1991, local people have increasing exploited the forest. Uncontrolled cutting down of trees continues as intense as before and is of major concern for conservation of the forest. The wood is sold in the nearby towns of Sebeta and Holleta. Wood for construction and fuel is taken to Addis Ababa where there is a high demand. Menagesha Suba State Forest Office employed a number of guards but they were not quite enough relative to the Forest area.

Trees plantations have been practiced mostly on the periphery of the forest and at any place where the vegetation is opened either by natural or anthropogenic factors. The planted species are mainly *Pinus radiata*, *Cupressus lusitanica*, *Juniperus procera*, *Podocarpus falcatus* and *Hagenia* *abyssinica.* The first modern tree nursery for the country was set up in 1949 in Suba, which is located near the forest, producing seedling of indigenous and exotic trees. The Forest plantation site has its lower boundary at the elevation of 2,400 and extends up to 2,700 m, while the slope varies between 2 and 55%. The soils are derived from basaltic trachyte rocks and are shallow brown on steep slopes and deep red in the depressions and on gentle slopes (Sebsebe Demissew 1988; Zewdu Eshetu, 2000).

2.2 Vegetation Description and Plant Community

Vegetation may be characterized either by their component species or the combination of structural and functional attributes that characterize them. Vegetation structure is the organization in space of the individuals that form a community and by extension a vegetation type or plant association (Muller-Dombois and Ellenberg, 1974). It is the spatial pattern of growth forms in a plant community, especially with regard to their height, abundance or coverage within the individual layer (Jennings *et al.*, 2003). Functional characters are those that provide an adaptive role which help the survival of organisms in the present and past environments (Goldsmith *et al.*, 1986). The two principal methods of vegetation description are physiognomic or structural and floristic (species composition) methods (Kent and Coker, 1992). Vegetation classification is a powerful tool for several purposes. The primary goal of this classification is to arrange vegetation patterns into an ecologically meaningful set of types, with clear criteria for identifying the types. It helps for efficient communication, data reduction and synthesis, interpretation and land management and planning. It also provides one way of summarizing our knowledge of vegetation patterns (Jennings *et al.*, 2003; Don *et al.*, 2007).

According to Kent and Coker (1992), plant community can be defined as the collection of plant species growing together in a particular location that shows a definite association with each other. It is the combination of plants that are dependent on their environment, influence one another and modify their own environment. Plant communities have been classified using floristic criteria, such as species composition, and their percent cover (Muller Dombois and Ellenberg, 1974). As stated in Kent and Coker (1992), among the species that make up the floristic composition of a community, some are more sensitive expressions of a given relationship than others do. Thus, using such species for practical classification, for identification of environment and ecological relationships make them the most effective indicators (Westhoff and van der Maarel, 1978). Indicator species are the most characteristics of each group which have a strong relationship with the environment (Mc Geoch *et al.*, 2002; Kotwal *et al.*, 2008). These ecological indicators can be used to assess the condition/situation of the environment, to provide an early warning signal of changes in the environment to diagnose the cause of an environmental difficulty.

2.3 Species Diversity, Richness and Similarity

The description of plant communities involves the analysis of plant diversity, evenness and similarity (Whittaker, 1975). Diversity and equitability (evenness) of species in a given plant community are used to interpret the relative variations between and within the community and helps to explain the main reason for such a difference. Species diversity has been identified as one of the key indices of sustainable land use practices and considerable resources are expended to identify and implement strategies that will reverse the current decline in biodiversity at local, regional and international scales (Schackelton, 2000). Understanding the variation in plant diversity patterns of different scales is an important topic and crucial for both ecological explanations and for effective conservation design (Devries *et al*., 1997). Thus, patterns of plant species diversity have often been noted for prioritizing conservation activities since they reflect the underlying ecological processes that are important for management (Lovett *et al*., 2000). The two main factors taken into account when measuring species diversity are richness and evenness. Species diversity is a measure of the diversity within an ecological community that incorporates both species richness (the number of species in a community) and the evenness of species' abundances. Richness is a measure of the number of different species in a given site and can be expressed in a mathematical index to compare diversity between sites. Species richness refers to the total number of species in a community while evenness is the relative abundance of species within the sample or community (Kent and Coker, 1992). Diversity is, thus, measured by recording the number of species and their relative abundances.

In vegetation ecology, various diversity indices have been computed for the measurements of diversity among which the Shannon-Wiener and Simpson diversity indices are the most commonly used ones (Magurran, 1988; Kent and Coker, 1992). Probably the Shannon-Wiener diversity index is used to calculate the diversity and evenness which naturally varies between 1.5 and 3.5 and rarely exceeds 4.5 (Kent and Cooker, 1992). It is widely used index that combines richness and evenness (Krebs, 1999). Species diversity could be viewed from different approaches in terms of alpha, beta and gamma diversity (Rosenzweig, 1995). Alpha diversity (α) refers to the diversity of species within a particular habitat or community. Beta diversity (β) is a measure of the rate and extent of change in species along a gradient from one habitat to another. It is between habitat diversity that measures turnover rates. Beta diversity is sometimes called habitat diversity (Kent and Cooker, 1992). Gamma diversity (γ) on the other hand is the diversity of species in comparable habitats along geographical gradients and is independent of the two (Kent and Cooker, 1992; Buley, 2001).

Similarity index measures the degree to which the species composition of the quadrats/samples is alike, whereas dissimilarity coefficient evaluates which two samples/ quadrats differ in composition. It can be used to assess the similarity between different habitats with reference to the composition of species. Jaccard and Sorensen are the most common binary similarity coefficient, because they rely on probability data, except that Sorensen gives more weight to the species that are present in both quadrats and therefore less weight to species that are present in only one quadrat (Kent and Cooker, 1992).

2.4 Environmental Gradient and Vegetation Patterns

Globally, patterns of plant species diversity are influenced by latitudinal, altitudinal and soil gradients (Huston, 1994). The interacting influences of climate, topography and soil are primary determinants of plant distribution so that variables such as vegetation structure and productivity also exhibit complex patterns along environmental gradient (Brown, 2001). Altitude affects temperature, moisture, radiation and atmospheric pressure thereby influencing the growth and development of plants and the distribution of vegetation (Zerihun Woldu *et al.*, 1989; Getachew Tadesse *et al.*, 2005). Species diversity generally tends to decrease with increasing altitude (elevation) (Whittaker, 1975). Vegetation structure and species composition of tropical forests characteristically undergo changes along altitudinal gradients (Homeier, 2008). In addition to elevation, topography is an important factor affecting vegetation structure and species diversity, by providing micro-habitat heterogeneity (Clark *et al.*, 1999; cited in Homeier, 2008). Topography is a complex factor and relates to hydrology, nutrient dispersion, soil structure and wind exposure, which are difficult to disentangle.

3. MATERIALS AND METHODS

3.1 Description of Study the Area

3.1.1 Geographical Location

The present study was conducted in Menagesha Suba State Forest which is located in central part of the country 30 km south west of Addis Ababa. It is geographically located between $38^0 31'$ and $38^0 35'$ E and 9^0 $89'$ and 9^0 $00'$ N in Oromia National Regional State in central Ethiopia (Figure 1). Menagesha Suba State Forest is on the south–western slopes of Mt Wochacha which is a massive and 3,385 m high extinct volcano. The mountain sides are generally steep with ravines cut by streams and rivers. The southern base of the mountain is at 2200 m height and flanks the Bacho plains. Menagesha Suba State Forest covers 9,248 ha, and in 1990 plantation forest comprised 1,316 ha and natural forest 2,720 ha, the remainder being open farmland, grazing and bareland (BI, 2001).

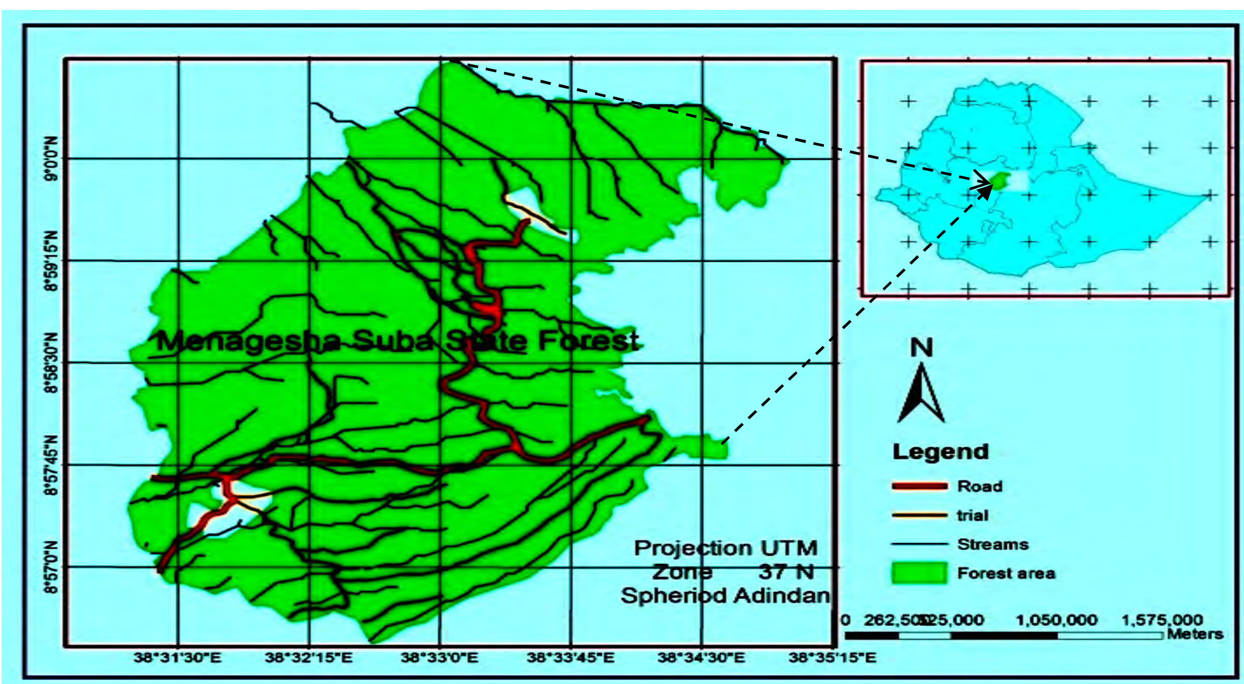

Figure 1 Map of the study area

3.1.2 Topography and Geology

The topographic feature of the area is extremely dissected, with alternating ridges and valleys dominating the landscape and consisted of a heterogeneous mix up of undulating plains, complex hill systems and gorges. (Feyera Senbeta and Demel Teketay, 2001; FAO, 2001).

As reported by (Miller *et al.*, 1966; cited in Sebsebe Demissew 1980), the geology of Wochacha is an extinct volcano situated in a very complex tectonic setting, where the western margin of the main Ethiopian rift is barely defined topographically. NE–SW faulting dominates the region, but without showing on the surface contrasting with the marked escarpments further north east. The rock types vary from a white coarsely porphyritic sandidine trachyte forming the Wochacha summit to an extensive series of pale to dark green or grey trachytes often porphyritic with feldspar phenocrysts at the lower altitudes, white, fine grained trachyte and trachytic tuffs of intermediate hardness at the summit depression and pale-yellow, coarsely porphyritic trachytes which are well developed (hard) on the southern slopes of the volcano.

Menagesha Suba State Forest is found on the southwest facing slopes of Mount Wochacha. This is an extinct volcano. The crystalline cone, Dhamocha, at the summit reaches 3,385 m (MOARD, 2002). The sides of the mountain slope down to the Bacho plains at 2200 m to the south. On the east are foothills at around 2400 m. The mountain is a source for several rivers including the Akaki River that flow and runs through the city of Addis Ababa.

3.1.3 Soil and Climate

The soils of the study area are shallower and light brown with rocky substrate at higher altitudes and deep, reddish-brown and less gravelly at lower altitudes (Tamrat Bekele, 1993). Annual rainfall is around 1100 mm with the rains mainly falling from June to September.

However, it can also rain in any month of the year and the Forest gets additional moisture from low clouds and mist. The annual temperature of the surrounding area is 16^{0}C with a mean maximum of 22.5^{0}C and mean minimum of 9.5^{0}C. The mean annual rainfall is estimated to be about 1225 mm and the mean monthly temperature ranges from 12.4 to 15.9^{o}C (Tamrat Bekele 1993). In the forest, the overall temperatures are cooler with an average of 11^{0}C in the upper parts. Currently, the annual temperature of the surrounding area is 17.1^{0}C with the mean maximum of 25.6^{0}C and mean minimum of 8.2^{0}C and the mean annual rainfall of 1314 mm (Figure 2).

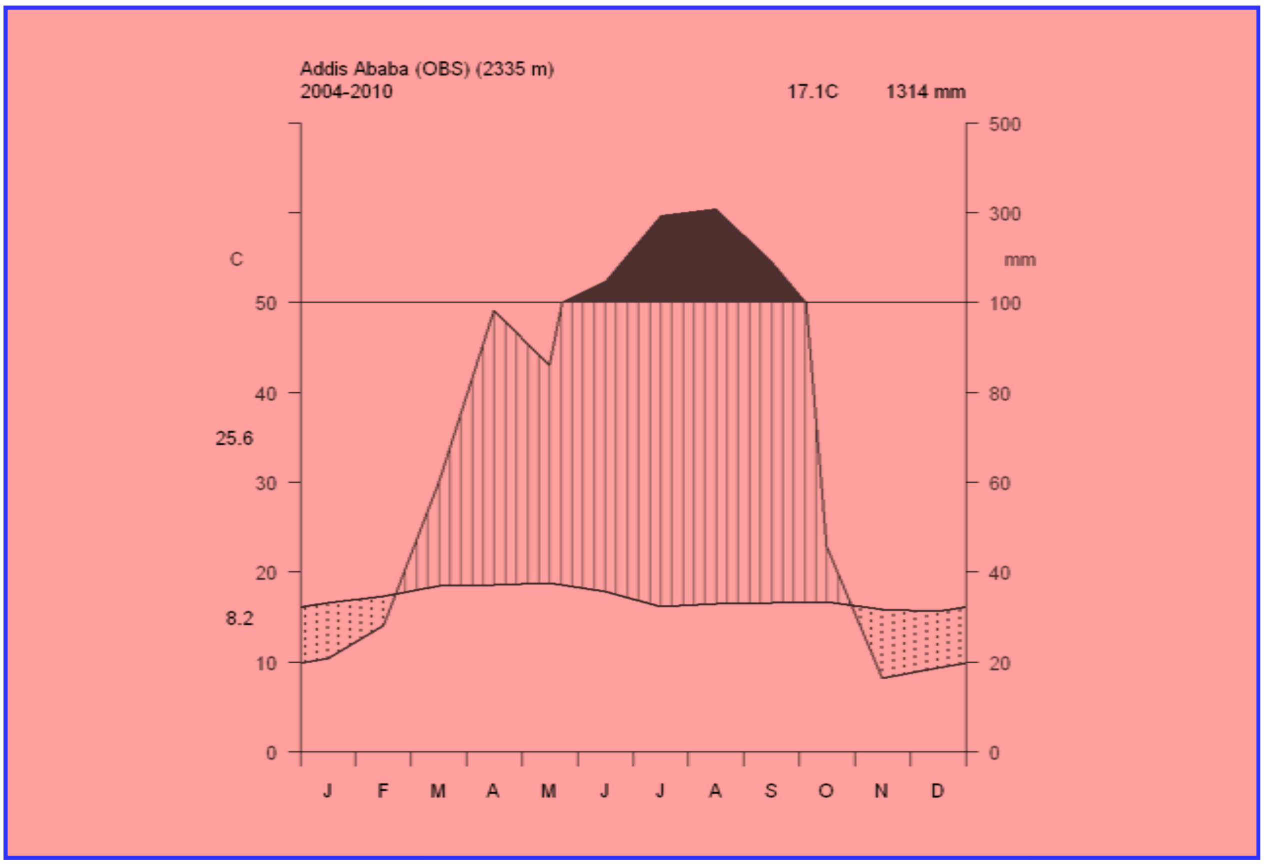

Figure 2 Climate diagram of Menagesha Suba State Forest and the surrounding areas (based on data recorded in Addis Ababa, Data Source: EMSA, 2011).

3.1.4 Ecology

Dry evergreen afro-montane forest together with grassland and *Acacia* woodland once believed to have formed a vegetation mosaic across the Ethiopian plateau. The forests and woodlands occur on the better drained soils of the mountains and sides of the valleys while the grassland occupies the heavy clay soils at the bottoms of the valleys. Over the several thousand years since farming started in Ethiopia, most of the natural vegetation has been replaced by the patchwork of homesteads and fields. The officially protected area of the Forest used to be 9,248 ha, but only about 2,500 ha of the original forest now remains with a further 1,000 ha under plantation. The rest consists of settlements, farmland and grazing land areas and the forest holds different wildlife animals including endemic Menelik's Bushbuck (Abate Zewede, 2006).

3.1.5 Land Use Systems and Practices

In the community surrounding the current study area, cereal farming is the most dominant land use practice and the community is mainly agrarian. Furthermore, cereal cropping and livestock production were the major land uses, with fuel-wood forestry rapidly increasing in importance. Teff, wheat, barley, maize and sorghum were the principal crops, and livestock comprised mainly cattle, sheep, goats, donkeys and horses (FAO, 2001). As most land is used for cereal growing, the relative proportion of land allocated to trees and shrubs is low. Farmers are using these trees and shrubs for construction wood, fuel-wood, animal feed and other ecological services. It is also indicated that construction wood, animal feed and minor construction woods are the scarcest forest products among the households located outside the state forest. There has been strong tenure insecurity among the community in the study area especially during 1980s because of the expansion plan for the State Forest by the then socialist government ruling the country. Accordingly, many farm households living inside and around the State Forest were displaced and translocated to other places. The farmers reinvaded the land they lost previously after the fall of the socialist government in the early 1990s (Lalisa Alemayehu and Hager, 2009).

3.1.6 Wildlife

The other most important feature of Menagesha Suba State Forest is the presence of various wild animals found in the forest, besides the age old trees in the park. A survey made in 2001 has proved the presence of 32 species of mammals and 186 species of birds in the Forest. Two of the wild mammals as well as four of the birds are endemic to the Forest. Feyera Senbeta and Demel Teketay (2001) further reported that, the Forest harbours numerous wild animals, including baboons, colobus monkeys, bushbucks, bush pigs, ghenet, caracal, spotted hyena, wildcat and a variety of bird species.

3.1.7 Natural Vegetation

According to MOARD (2002), the Natural Forest of Menagesha Suba State Forest is dominated by J*uniperus procera* that grows to c. 30 m and forms a relatively open canopy. *Olea europaea* subsp *cuspidata*, *Allophyllus abyssinicus*, *Maytenus arbutifolia* and *Euphorbia ampliphylla* form the understory, and some *Podocarpus falcatus* trees are scattered throughout the forest. At higher altitudes, smaller *Juniperus procera* are mixed with *Erica arborea*, *Rosa abyssinica* and the endemic *Jasminum stans*. Two giant herbs, *Lobelia giberroa* and *Solanecio gigas* dominate the sides of the valleys; the striking *Scadoxus multiflorus* carpets the forest floor.

3.2 Vegetation Data Collection, Identification and Analysis

3.2.1 Reconnaissance Survey and Sampling Design

Reconnaissance survey was conducted in the first week of November 2010, to collect baseline information, to have a mental picture and visual information on the area under study in relation to its vegetation distribution and topographic nature, to get an impression of the site conditions, to identify the possible sampling sites and the number of transect lines to be laid down across the Forest. This preliminary survey was aimed at identifying the plant community type and their distribution and to have a better familiarization with the study area. The sampling design used for study was systematic sampling in which three transect lines were laid down from the base to the top of the mountain along altitudinal gradient having different number of plots depending on the length of the transect lines. The three transect lines were laid down paralleling to each other at the interval of 400 m throughout the entire Forest and a total of about 75 sample plots/quadrants of 20 m x 20 m ($400\ m^2$) were placed at 100 m altitudinal rise up between each plot/quadrat. Finally, five sub–plots 1 m x 1 m ($1\ m^2$) in which four sub–plots were laid down at each corner and one from the middle of the main sample plot for herbaceous flowering plants were used to gather vegetation data.

3.2.2 Vegetation Data Collection and Identification

Altitude was measured for each sample plot using 'Pretel digital altimeter, and Magellan NAV5000 Pro GPS was used to record the latitude and longitude coordinates. Then, complete lists of herbaceous flowering plants were made for each sample plot throughout the entire area under the study. Plant specimens were collected, pressed and dried in the field. Specimen identification and documentation was done at the National Herbarium of (ETH), Addis Ababa

University, and using specimens from the Herbarium, published volumes of the Flora of Ethiopia and Eritrea, student thesis such as, Kitessa Hundera (2007), Birhanu Kebede (2010), Abiyou Tilahun (2009), Abate Zewdie (2006) and Honeybee Flora of Ethiopia (Fichtl and Admasu Adi, 1994) and others.

3.2.3 Density, Frequency and Abundance

Density is defined as the number of plants of a certain species per unit area (Hutchings, 1997). **Population density** refers to a count of the number of all individual plants per species within the quadrats i.e., total number of individuals in the species per unit area (Kent and Coker, 1992). **Frequency** is the number of times a species occurs in subplots within the sample plot or within an undelimited phytocoenosis (formally plotless sampling). Frequency is defined as a chance of finding a species in particular area in a particular trial samples or the proportion of sample quadrats in which individuals of species are recorded. It is obtained by using quadrats and expressed as the number of quadrats occupied by a given species per number thrown or more often as a percentage (Goldsmith *et al.*, 1986). It is a measure of occurrence of a given species in a given area. It indicates how the species are dispersed and is an ecological meaningful parameter. In other words, it gives an approximate indication of the homogeneity of the stand under consideration (Kent and Coker, 1992). The frequency value obtained reflects the patterns of distribution and as well as the diversity of species.

$$\textbf{Frequency} = \frac{\text{Number of quadrats in which a species occur}}{\text{Total number of quadrats throughout the study site}} \times 100$$

Frequency measures the uniformity of the distribution of the species in the study area (Silverttown and Doust, 1993 as cited in Abeje Eshete *et al.*, 2005). It gives an approximate homogeneity of the stands (Kent and Coker, 1992). The higher the frequency the more important the plant is in the community. The high frequency value of a given plant species in the community indicates that it is widely distributed in the area under the study (Dereje Denu, 2007).

Abundance is the number of plant per unit area. Measurement of plant abundance requires the counting of individual plants by species in a given area. It can be used to show spatial distribution and ranges over time.

3.3 Data Analysis

3.3.1 Multivariate Vegetation Data Analysis

In ecological work, multivariate techniques are used to generate hypothesis about the relationship between species composition and environmental factors (Leps and Smilauer, 2003). The most common multivariate technique to analyze plant communities is classification by means of cluster analysis. Therefore, in this study, a hierarchical cluster analysis was made by using PC–ORD for windows version 5.0 (McCune and Mefford, 1999; McCune and Grace, 2002) to classify the vegetation into plant community types. For the cluster analysis, abundance data of the 106 species were used. In the analysis, the Relative Euclidean Distance (RED) was implemented to eliminate the differences in the total abundance among sample units; and the Ward's method was used in order to minimize the total within group mean of squares or residual sum of squares (McCune and Grace, 2002). The floristic data analysis was done based on 106 species that were recorded and collected within the sampled plots.

3.3.2 Diversity Indices

3.3.3 Diversity and similarity indices

Diversity indices measure the degree of uncertainty (if the diversity is high in a given habitat, the sureness of finding a particular species is low). They are simple mathematical expressions that summarize a lot of data recorded in one or sets of figures. Of the various indices, Shannon-Wiener diversity index (H') is the most applicable index of diversity (Grieg-Smith, 1983). It was used to compute for species richness, species evenness and species diversity of the plant community types in the vegetation. This diversity index is the most popular measure of species diversity because it accounts both for species richness and evenness regardless of the sample size (Kent and Coker, 1992; Krebs, 1999). The value of Shannon diversity index is usually between 1.5 and 3.5 and only rarely exceeds 4.5 (Magurran, 1988).

I. **Shannon and Wiener (1949) diversity index** is calculated by using the following mathematical expressions:

$$\mathbf{H' = -\sum_{i=1}^{s} p_i \ln pi}$$

Where:

H' = Shannon Diversity Index

s= the number of species

Pi= the proportion of individuals or the abundance of the i_{th} species expressed as a proportion of total cover and ln= natural logarithm.

II. Evenness (Equitability)

The fundamental means of analyzing floristic vegetation data is to look at the degree of association between species and level of similarity between quadrats or samples. Evenness is used to quantify the unique representation of a given species against a given hypothetical community in which all species are equally common, such that when all species have equal abundance in the community and hence evenness is maximal (Kent and Coker, 1992; Krebs, 1999). Equitability (Evenness) index is calculated using the formula:

$J = \frac{H`}{\ln(S)}$, Where **J** = Evenness, **H`** = Shannon–Diversity Index, **S**= total number of species in the sample and **ln** = natural logarithm

The value of evenness index falls between 0 and 1. The higher the value of evenness index, the more even the species is in their distribution within the given area.

III. Similarity coefficient – Sorensen`s similarity was used to determine the pattern of species turnover among successive communities. Its coefficient value ranges from 0 (complete dissimilarity) to 1 (total similarity). Floristic similarity is calculated by the following formula (Kent and Coker, 1992; Krebs, 1999).

Ss = 2a/ (2a+b+c), Where:

Ss=Sorensen's similarity coefficient

a= is number of species shared by the two forests/ samples;

b= is the number of species in forest/ sample 1(community1);

c= is the number of species in forest/ sample2 (community2) Kent and Coker (1992).

4. RESULTS AND DISCUSSION

4.1 Floristic Composition

Table 1 The abundance (dominance), diversity, patterns and distribution of species collected from Menagesha Suba State Forest with their respective number of families, genera and species.

No	Family	Genus	%	Species	%
1.	Acanthaceae	4	4	4	3
2.	Apiaceae	6	6	6	5
3.	Asclepiadaceae	4	6	4	3
4.	Asteraceae	20	20	31	24
5.	Convolvulaceae	3	3	5	4
6.	Cyperaceae	3	3	3	2
7.	Fabaceae	4	4	5	4
8.	Lamiaceae	4	4	5	4
9.	Plantaginaceae	3	3	3	2
10.	Poaceae	9	9	11	9
11.	Solanaceae	3	3	4	3
12.	Other 33 Families	38	37	44	34
Total	44	102	100	128	100

A totality of 128 species of herbaceous flowering plants belonging to 102 genera and 44 families were documented from Menagesha Suba State Natural Forest (Appendix 1). Asteraceae is the most dominant family with 31 species (24%) and 20 genera (19.6%), followed by Poaceae with 11 species (8.59%) and nine genera (8.25%). Apiaceae is also amongst the dominant regarding its species and generic composition compared with others with six species (4.7%) and six genera (5.9%). These three families together contributed about 37.3% of the total species and 33.4% of the total genera. Following the above three dominant herbaceous flowering plant families, Acanthaceae, Asclipiadaceae, Fabaceae and Lamiaceae each contributing four genera, followed by Convoluvulaceae, Cyperaceae, Plantaginaceae and Solanaceae each comprising of three genera with different number of species(Table 1). On the other hand, the remaining 33 families were found to be represented by less than three genera and species each, i.e., 11 families with two genera and two or more than two species each and 22 families with one genus and one or more than one species each.

4.1.1 Endemic Plants in Menagesha Suba State Natural Forest

Menagesha Suba State Natural Forest constitutes 14 (11%) endemic species drawn from six families (Table 2). Asteraceae is the largest family and genus in terms of endemicity occupying 57% and followed by Lamiaceae covering 14% of the total endemic species. The remaining four families contains one species each and altogether covered 29% of the overall endemicity. The conservation status of endemic plant species of the Forest was evaluated based on Vivero *et al*, (2005a; 2005b) and IUCN (2001). The majority of the endemic plants of the Forest are not under immediate threat based on the information of IUCN categories; although two species have been considered endangered (EN) while further two species have been assessed as vulnerable (VU). These four threatened taxa require strict conservation measures put in place as soon as ever possible in order to ensure their survival.

Table 2 Endemic herbaceous flowering plant species collected from Menagesha Suba State Forest (IUCN categories: CR = Critically Endangered, LC = Least Concern; NT = Not Threatened and VU = Vulnerable).

No	Endemic Herbaceous Flowering Plants	Family	IUCN Category	Distribution in Ethiopia*
1	*Carum piovanii*	Apiaceae	VU	WU, SU
2	*Cineraria abyssinica*	Asteraceae	LC	GD, WU, SU, AR, SD, BA
3	*Conyza spinosa*	Asteraceae	VU	GJ, WU, SU, BA
4	*Crassocephalum macropappum*	Asteraceae	LC	GD, GJ, WU, SU, WG, IL, KF, GG, SD, BA, HA
5	*Holothrix unifolia*	Orchidaceae	EN	GD, SU
6	*Hyparrhenia arrhenobasis*	Poaceae	EN	GJ, SU
7	*Inula confertiflora*	Asteraceae	*NT*	EW, WU, SU, AR, BA, HA
8	*Kalanchoe petitiana*	Crassulaceae	LC	GD, GJ, WU, SU, GG, SD, AR, BA, HA
9	*Laggera tomentosa*	Asteraceae	NT	TU, GO, GJ, WU, SU, HA
10	*Mikaniopsis clematoides*	Asteraceae	LC	TU, GD, SU, HA, BA, AR, KF
11	*Plectocephalus varians*	Asteraceae	LC	EW, TU, GD, GJ, SU, AR, BA, KF, GG, SD, HA, WG
12	*Satureja paradoxa*	Lamiaceae	NT	GD, GJ, SU, AR, WG, IL, KF, GG, SD, BA, HA
13	*Solanecio gigas*	Asteraceae	LC	GD, GJ, WU, SU, BA, KF, IL
14	*Thymus schimperi*	Lamiaceae	LC	EW, TU, GD, WU, SU, AR, SD, BA, HA

*SD=Sidama, AR=Arsi, BA=Bale, GD=Gonder, WU=Wollo, GJ=Gojam, HA=Harage, EW=Eritrea West, KF=Kefa, IL=Illubabor, GG=Gamo Gofa, TU=Tigray, SU=Shewa (adopted from Flora of Ethiopia and Eritrea)

4.2 Vegetation Classification

4.2.1 Identification of Plant Communities

Five clusters were produced or identified at 50% similarity scale from the output of PC–ORD computer programme that characterizes the plant communities of the Forest. The plant communities have been named after two or more dominant species have been selected based on (characteristic or diagnostic species) or species with the highest mean abundance value that appears within a cluster. The value selected in order to come out with the characteristic species is also on the basis of the synoptic table (Appendix 3). Every plant community has its own characteristic species and has usually one or more dominant species and the description of the plant community types with their altitudinal distribution is given below.

4.2.1.1 *Hypoestes triflora* Community Type

Based on the mean of abundance value of species in the community, the most dominant/characteristics species is *Hypoestes triflora* followed by *Cyperus tenuispica* and *Geranium arabicum.* Additionally, *Leptochloa rupestris*, *Achyranthes aspera*, *Agrocharis incognita*, and *Justicia ladanoides* are some of the species relatively dominating the community. This community comprises the largest number of quadrats (43 plots) in relation to others and its altitudinal range or distribution falls between 2450–2951 m a.s.l (Tables 3). The reason that *Hypoestes triflora* is the most outstanding in its abundance is suggested to be due to its adaptive resistance towards grazing animal and anthropogenic impacts.

4.2.1.2 *Hypoestes triflora- Crassula alsinoides-Geranium arabicum* Community Type

As shown in (Table 3), the mean abundance value of *Hypoestes triflora* is twice abundant as the abundance mean value of *Crassula alsinoides* and *Geranium arabicum* which is also less prone to disturbances than do both of the species. Altitudinal limitation of this community type seems to lie between 2413–2674 m a.s.l. The community is made up of about 5–plots in which *Leptochloa rupestris*, *Achyranthes aspera* and *Agrocharis incognita* significantly contribute to the dominancy effect within the community. While the remaining other species are highly insignificant with regards to their abundance in the community and this implies that those characteristic species will highly express themselves than usual.

4.2.1.3 *Justicia ladanoides-Hypoestes triflora* Community Type

In this community type, *Justicia ladanoides* is the most widely and frequently occurring species followed by *Hypoestes triflora* with abundance value of 125.9 and 89.67 respectively. The community constitutes of 15 plots/quadrats and is the second largest community in containing high number of plots. The community is situated in the altitudinal range between 2410–2910 m a.s.l. Finally, the former two taxa best represent the characteristic species of the community and the other species which take part in the dominancy are *Cyperus tenuispica*, *Geranium arabicum*, *Achyranthes aspera* and *Agrocharis incognita* to the total composition of the community.

4.2.1.4 *Geranium arabicum* Community Type

This community type contains/harbours six plots and distributed in the range of 2434–2896 m. a.s.l. Under community four, the most dominant herbaceous flowering plant is *Geranium arabicum* which is absolutely the only diagnostic species of the community. *Crassula alsinoides* and *Justicia ladanoides* are the most common in occurrence as compared to the other species with the lower abundance mean value.

4.2.1.5 *Trifolium acaule - Hypoestes triflora* Community Type

The species which abundantly covers this community includes *Justicia ladanoides*, *Geranium arabicum*, *Alchemilla pedata* and *A. abyssinica*, but contributing with little variation in their mean abundance values with the characteristic species *(Trifolium acaule* and *Hypoestes triflera)* of the community. Under this community, on the average, the characteristic species are occurring almost evenly i.e. the abundance mean value of each species is approximately similar with each other. The community is composed of six plots and dispersed in the altitude range of 2469-2890 m.a.s.l.

Diagrammatic representation of plot versus species dendrogram

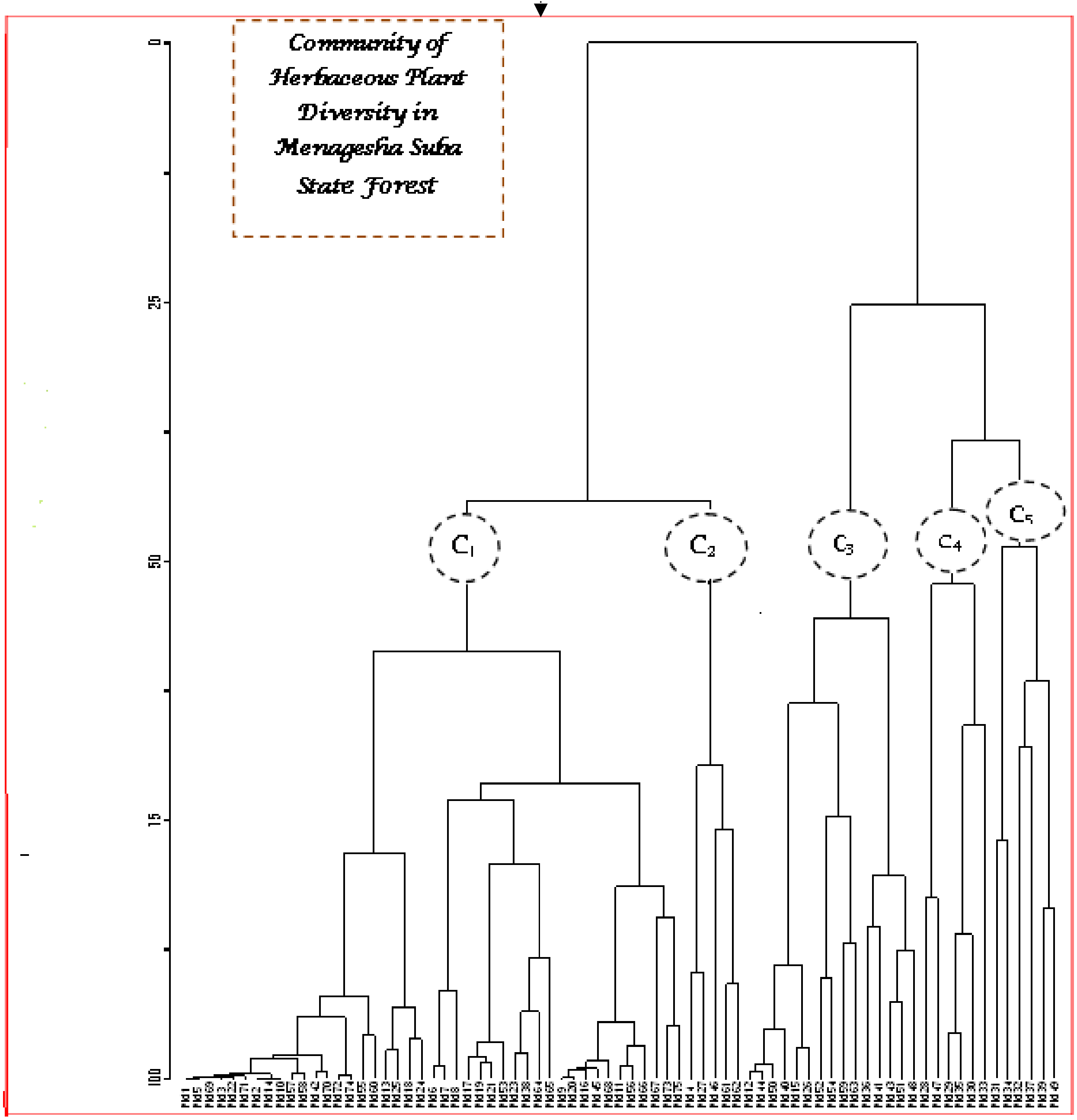

Figure 3 Dendrogram representing plant community types of the area (C_1-Community 1, C_2-Community 2, C_3-Community 3, C_4-Community 4, and C_5-Community 5)

Table 3 Shows plant communities, major species, species richness, altitude and number of plots in each community.

Community types	Plots in each community	Major species in each community	Species richness	Altitudinal range (m)	No of plots
C_1	1, 3, 69, 5, 22, 71 2, 14, 10, 57, 58 42, 70, 72, 74, 55 60, 13, 25, 18, 24, 6 7, 8, 17, 19, 21, 53 23, 38, 64, 65, 9 20, 16, 45, 68, 11 56, 66, 67, 73, 75	*Agrocharis incognita* *Achyranthes aspera* *Cyperus tenuispica* *Hypoestes triflora* *Justicia ladanoides* *Leptochloa rupestris* *Lolium temulentum*	21.5	2450-2951	43
C_2	4, 27, 46, 61, 62	*Agrocharis incognita* *Achyranthes aspera* *Crassula alsinoides* *Geranium arabicum* *Hypoestes triflora* *Leptochloa rupestris* *Geranium ocellatum*	25.2	2413- 2674	5
C_3	2, 44, 50, 40, 15 26, 52, 54, 59, 63 36, 41, 43, 51, 48	*Cyperus tenuispica* *Geranium arabicum* *Lolium temulentum* *Justicia ladanoides* *Hypoestes triflora*	21. 27	2410-2910	15
C_4	28, 47, 29, 35, 30 33	*Crassula alsinoides* *Geranium arabicum* *Geranium ocellatum*	23	2434-2896	6

		Justicia ladanoides			
		Leptochloa rupestris			
		Alchemilla abyssinica			
		Helichrysum stenopterum			
C_5	31, 34, 32, 37, 39	*Alchemilla pedata*			
		Cyperus tenuispica	**24.8**	2469-2890	**5**
	49	*Geranium arabicum*			
		Hypoestes triflora			
		Trifolium acaule			
		Mikaniopsis clematoides			

Table 4 Synoptic abundance value for species reaching a value of › 10 in at least one community type (value in bold refers to characteristic species C1-community 1, C2-community 2, C3-community 3, C4-community 4, C5-community 5)

Species	C1	C2	C3	C4	C5
Hypoestes triflora	**253**	117	89.67	0	48.3
Cyperus tenuispica	**34.95**	0	40.9	0	0
Geranium arabicum	**27.4**	63.8	26.5	176.7	46.8
Achyranthes aspera	21.4	**21.6**	17.4	0	5
Crassula alsinoides	0	**75.6**	0	24	0
Leptochloa rupestris	20.7	**31.2**	11.6	0	0
Agrocharis incognita	20.3	21.6	**17.4**	0	0
Justicia ladanoides	18.9	16.4	**125.9**	21.2	0
Lolium temulentum	9.25	0	**14.9**	0	0
Helichrysum stenopterum	0	0	6	**10.7**	0
Geranium ocellatum	0	13.6	0	**13.2**	0
Mikaniopsis clematoides	2	9	0	**4**	10.9
Alchemilla pedata	0.2	0	3	0	**45.8**
Trifolium acaule	0	0	0	0	**55.8**
Alchemilla abyssinica	0	0	0	0	**28.2**
Nigella damascena	0	12.6	0	0	0

4.3. Species Diversity, Richness and Evenness of the Plant Communities

Shannon and Wiener (1949) diversity index was used to compute the analysis for the five communities. Accordingly, Community Type II, IV and V are the most richest and diverse in terms of species composition and have even distribution of species indicating that the vegetation is expected to be with less intervention of humans and domestic animals. The high value of species richness has a great importance in buffering taxonomic and ecological diversity of the Forest ecosystem. Community III shows the least in terms of its species richness, which may be due to pressure by humans and domestic grazing animals in the upper and lower portion of the Forest where human settlements have been observed (Table 5). The exceptional case to Menagesha Suba State Forest is the upper and lower part of the Forest is occupied by local population or settlements. The variability of each magnitude in each parameter for different community types may be due to difference in their species composition, and degree of disturbance involved by anthropogenic and environmental factors.

Table 5 Shannon and Wiener diversity index

Communities	Average altitude in (m)	Species richness (S)	Species evenness (E)	Diversity index (H')	Simpson's index (D)
I	2450-2951	55	0.961	3.851	0.9756
II	2413- 2674	59	0.967	3.944	0.9787
III	2410-2910	53	0.891	3.538	0.9623
IV	2434-2896	63	0.942	3.971	0.9486
V	2469-2890	65	0.953	3.994	0.9788

Jaccard's Similarity Index

Jaccard's coefficient (measure similarity) and Jaccard's distance (measure dissimilarity) are measurement of asymmetric information on binary (and non-binary) variables. Also known as the Jaccard index, the Jaccard similarity coefficient is a statistical measure of similarity between sample sets. For two sets, it is defined as the cardinality of their intersection divided by the cardinality of their union (Jaccard, 1912).

Mathematically it is expressed as $J(A; B) = \frac{[A \cap B]}{[A \cup B]}$, in this case A and B refers to the community types

The Jaccard similarity can be used, when interested in binary differences between two or more objects. Especially in ecological research investigations often focus on the presence/absence between several sites. When interested in characterizing compared sites by the possibility of species to settle their abundances are often negligible.

Table 6 Jaccard's similarity coefficient among the five communities

Communities	I	II	III	IV	V
I	1				
II	0.4	1			
III	0.57	0.2	1		
IV	0.17	0.4	0.2	1	
V	0.3	0.18	0.38	0.08	1

The highest similarity coefficient was recorded between communities III and I (57%), II and I, IV and II, (40%) respectively and the second highest similarity value has been observed between

V and III (38%), and V and I (30%). The highest dissimilarity had been recorded for communities V and IV (8%) similarity coefficient (Table 6).

4.4 Phytogeographical Comparison

The result attained demonstrates that, Menagesha Suba State Forest is one of the diversified dry evergreen montane forests in the country containing a minimum of 128 herbaceous flowering plant species. The direct comparison of the species diversity of a given forest with others is not feasible due to differences in size of forests, survey methods, and objective of the study (Tadesse Woldemariam, 2003). However, the overall species richness of the forest can give more or less a general impression of their diversity and phytogeographical similarity. The most characteristic plant species in the current study area includes *Achyranthes aspera*, *Agrocharis incognita*, *Alchemilla abyssinica*, *A. pedata Crassula alsinoides*, *Cyperus tenuispica*, *Geranium arabicum*, *G. ocellatum*, *Hypoestes triflora*, *Justicia ladanoides*, *Leptochloa rupestris and Trifolium acaule*. The dry evergreen montane forest is a complex vegetation type occurring in the highlands at altitudinal range of 1500-3400 m a.s.l. and has average annual temperature and rainfall of 14-25°C and 500-1500 mm respectively (IBC, 2001). Thus, the altitudinal limit of Menagesha Suba State Natural Forest is between 2350 - 3300 m.a.s.l (Abate Zewdie, 2006). Menagesha Suba State Forest is compared with eight dry afromontane forests such as BMNP; Bale Mountain National Park, Gedo, Menagesha Amba Mariam, Gullele Botanical Garden, Sanka Meda, Magada, Adaba-Dodola and Denkoro (Table 7).

These forests were compared with the Forest under the study based on their similarities in species diversity. Sorensen's similarity index is used for comparison of the above forests using a formula:

SI= 2a / (2a + b + c) where, **SI** = Sorensen`s similarity coefficient,

a = common to and the forest in comparison,

b = found only in the Forest under study and

c = found only in the forest in comparison with Menagesha Suba State Forest.

Table 7 Demonstration of comparison of similarities of herbaceous flowering plant species composition between Menagesha Suba State Forest and other dry afromontane forests in Ethiopia.

Forests used for comparison with their respective author and Year		**Altitude (m)**	**Species richness**	a	**b**	c	**SI**
1	BMNP (Haile Yineger (2005)	2441-3600	130	22	104	108	0.17
2	Denkoro (Abate Ayalew, 2003)	1500-3500	104	23	105	81	0.20
3	Gedo (Brihanu Kebede, 2010)	2300-3000	86	20	108	66	0.19
4	Sanka Meda (Shambel Bantewalu, 2010)	2400-2748	53	14	114	39	0.15
5	Menagesha Amba Mariam (Abiyou Tilahun, 2009)	2574-2948	147	38	90	109	0.28
6	GBG	2550-2960	156	42	86	114	0.30
7	Magada: Genene Bekele, 2005	1750-2100	77	12	116	66	0.12
8	Adaba-Dodola Kitessa Hundera *etal.*, 2007	2500-3500	57	22	106	35	0.24

***Note that the species richness of those forests in comparison with Menagesha Suba State Forest is only with respect to their herbaceous flowering plants diversity excluding their woody plants and ferns.**

Table 7 indicates that Menagesha Suba State Forest has the highest species similarity with the forest of Gullele Botanical Garden and Menagesha Amba Mariam Forest having similarity coefficient of (30%) and (28%) respectively. Secondly, Adaba-Dodola (24%) and Denkoro (20%) forests are a slightly similar with the Forest under study relative to others. The Forest of BMNP (Bale Mountain National Park), Sanka Meda and Magada are highly dissimilar to Menagesha Suba State Forest with similarity coefficient of (17%), (15%) and (12%) correspondingly. The overall close similarity and difference are perhaps attributable to their geographical proximity, climatic zones, altitudinal range, and the geologic make up that lead to variation and resemblance in their vegetation pattern and distribution.

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The study has provided essential information on the herbaceous flowering plant diversity which indicates the management and conservation status of the forest currently. Results confirmed that 128 species of herbaceous flowering plants were collected and identified which belong to 102 genera and 44 families. The family Asteraceae is the most dominant with 31 species and 20 genera; Poaceae is the second dominant family with 11 species and 9 genera. The third important herbaceous flowering plant family with six species and six genera was Apiaceae in relation to other remaining families. Fourthly, Acanthaceae, Lamiaceae, Asclepiadaceae and Fabaceae are composed of four genera and varying number of species. Fifthly, Convolvulaceae, Boraginaceae, Plantaginaceae and Solanaceae were families which harbour three genera and different numbers of species. There are 33 (75%) of families represented by one genus and one or more species.

The study revealed that among the 128 species 14 (11%) of the herbaceous flowering plant species are endemic to the Ethiopian and Eritrean Flora area, most of which are under least concern; four of them are threatened as vulnerable and endangered regarding their conservation status, while 11 species are strictly endemic to Ethiopia (Table 2). Most of the endemic plants belong to the family Asteraceae comprising 57% and Lamiaceae 14% of the total endemicity of the Forest herbaceous flowering plant diversity.

The vegetation was clustered into five (5) herbaceous flowering plant community types at 50% similarity scale each of which had different degrees of species richness, diversity and evenness. The distributions of these plant communities in the Forest were influenced by various environmental factors and biotic pressures which are operated that are impressive in their combined effect leading to variations in species richness and composition of communities. The community types that were identified under the current study are Hypoestes triflora community type, Hypoestes triflora-Crassula alsinoides and Geranium arabicum community type, Justicia ladanoides-Hypoestes triflora community type, Geranium arabicum community type and Trifolium acaule-Hypoestes triflora community type based on the outputs of of PC-ORD computer programme. Phytogeographically, the present study Forest is highly similar to Gullele Botanical Garden and Menagesha Amba Mariam as compared to other dry evergreen montane forests on the subject of its vegetation pattern and composition.

5.2 Recommendations

Based on the results of this study the following suggestions or recommendations would be forwarded.

- Because of the current environmental degradation and global climate change, most forests in developing countries including Ethiopia suffer from many human impacts which emanate, from highly growing and expanding populations As a result, paying equal attention to herbaceous flowering plant diversity as to others is a better ever solution in restoration, rehabilitation and planning any conservation and management strategies to the ongoing high degradation of Ethiopian forest.

- In a natural forest the existence of high diversity of herbaceous flowering plant indicates the current status of the forest i.e. its less exposure to overgrazing, human induced fire, and reduced amount of exploitation. Therefore, it is recommendable to take care of those forests whose herbaceous flowering plants diversity had been lost and going to die in the near future in order to foster rapid conservation plan both at national and regional level before the resources get depleted to the level at which any recovery endeavor are impossible and to make an impression help to draw the interest of GOs and NGOs at all levels.

- In general, having these advantages of herbaceous flowering plant as indicators of the contemporary status of the forest they are considered the integral part the forest. In addition, herbaceous plants have different ecological importance such as reduction in water ran off, due to their short life cycle; they also add more nutrients to the soil which creates wide opportunities for the survival of higher plants in supplying the essential requirement and enhances the buffering activities of soil.

- Finally, further investigations mainly of ethnobotanical studies are also required to explore the wealth of indigenous knowledge on the diverse use of herabeous plants and their implication in conservation strategies of the Forest.

6. REFERENCES

Abate Ayalew (2003). A Floristic Composition and Structural Analysis of Denkoro Forest, South Wello. M.Sc. Thesis, Addis Ababa University, Addis Ababa.

Abate Zewdie (2006). Comparative Floristic study on Menagesha Suba State Forest on years 1980 and 2006, M. Sc. Thesis, Addis Ababa University; Addis Ababa, Ethiopia.

Abeje Eshete, Demel Teketay and Hulten, Håkan. 2005. The Socio-Economic Importance and Status of Populations of Boswellia papyrifera (Del.) Hochst in Northern Ethiopia: The Case of North Gondar Zone. Forests Trees and Livelihoods, 15:55-74.

Abiyou Tilahun (2008). Floristic Composition and Structure of Vegetations in Menagesha Amba Mariam Forest in Central highlands of Ethiopia. Unpublished M.Sc. Thesis Addis Ababa University, Addis Ababa.

Alemayehu Mengistu (2003). Country Pasture/Forage Resource Profiles. Addis Ababa, Ethiopia.

Badege Bishaw (1993). Determining Options for Agroforestry Systems for the Rehabilitation of Degraded Watersheds in Alemaya Basin. Hararghe Highlands, Ethiopia.

Badege Bishaw (2001). Deforestation and land degradations in the Ethiopian Highlands: strategy for physical recovery. *J. North East African Studies* **8**:7-26.

Berry, L. (2003). Land Degradation in Ethiopia: Its Extent and Impact. Commissioned by the GM with WB support, Ethiopia.

BI (2001). Menagesha State Forest: Ethiopian Wildlife and Natural History Society. Birdlife International, Addis Ababa, Ethiopia.

Birhanu Belay (2009). Floristic Composition and Ethnomedicinal Study of Vegetation in Gullele Botanic Garden (GBG). M.Sc thesis, Addis Ababa University, Addis Ababa.

Birhanu Kebede (2010). Floristic Composition and Structural Analysis of Gedo Dry Evergreen Montane Forest, West Shewa Zone of Oromia National Regional State, Central Ethiopia. M.Sc. Thesis, Addis Ababa University, Addis Ababa.

Booth, G. (2004). Ethiopia: Environmental Threats and Opportunities Assessment. Addis Ababa, Ethiopia.

Brady, N.C. (1994). Alternative to Slash and Burn: a global imperative. **In:** *Alternative to Slash-to-Burn Agriculture.* Sanchez P.A. and van Houten H. (eds). Symposium ID-6. Vol. 9, Supplement to Transactions. Proceedings of the Transactions of 15th World Congress of soil Science, July 10-16, Acapulco, Mexico. INEGI and CAN (Mexico).

Brenan, J. P. M. (1987). Some Aspects of the Phytogeography of Tropical Africa. *Annals of Missouri Botanical Garden,* **65:** 437-478.

Brown, J. H. (2001). Mammals on mountainsides: elevational patterns of diversity. *Glob. Ecol. and Biogeog.* **10**: 101-109.

Buley, J. (2001). The balance between biodiversity conservation and sustainable use of tropical rainforests: policy-relevant forest research. **In:** *The Balance between Biodiversity Conservation and Sustainable Use of Tropical Rain Forests.* PP. 13-18, (Hillegers, P.J.M. and de Iongh, H.H. eds.) Workshop proceedings. The tropenbos Foundation, Wageningen, The Netherlands.

Demel Teketay (1996). Seed Ecology and Regeneration in Dry Afromontane Forests of Ethiopia. Doctoral thesis, Swedish University of Agricultural Sciences, Umea. 36 p. + 5 Appendices.

Demel Teketay (2001). Deforestation, Wood Famine, and Environmental Degradation in Ethiopia's Highland Ecosystems: Urgent Need for Action. *Northeast African Studies,* Volume 8, Michigan State University Press.

Devries, P.J., Murray, D. and Lande, R. (1997). Species diversity in vertical, horizontal and temporal dimensions of a fruit feeding butterfly community in an Ecuadorian rainforest. *J. Linnean Society* **62:**343-364.

Don, L., Norm, A.,Kevin, H., Michael, S.L. and Drak, J. (2007). Vegetation classification, mapping and monitoring at Voyageurs National Park, Minnesota. An application of the U.S. National vegetation classification. J. Applied Vegetation Sci. 10: 361-374.

EFAP (1994). Ethiopian Forestry Action Program, Volume III. The Challenge for Development. Ministry of Natural Resources, Addis Ababa, Ethiopia.

Ehui, S.K. & Hertel, T.W. (1992). Testing the impact of deforestation on aggregate agricultural productivity. *Agricultural Ecosystem and Environment*, **38**(3): 205-218.

Ensermu Kelbessa and Teshome Soromessa (2008). Interfaces of regeneration, structure, diversity and uses of some plant species in Bonga Forest: A reservoir for wild coffee gene pool. *SINET: Ethiop. J. Sci.*, **31(2):** 121-134.

Ensermu Kelbessa, Sebsebe Demissew, Zerihun Woldu and Edwards, S. (1992). Some threatened Endemic Plants of Ethiopia. *NAPRECA* pp. **2**:35-55. No. **2,** Botany 2000: East and Central Africa.

Eshetu Yirdaw (2002). Diversity of naturally-regenerated native woody in forest plantations in the Ethiopian Highlands. *New Forests* **22**:159-177.

FAO (1996). Ethiopia: Country Report to the FAO International Technical Conference on Plant Genetic Resources. Leipzig, Germany.

FAO (2001). Grassland resource assessment for pastoral systems. FAO Plant Production and Protection Papers. Rome, Italy.

FAO (2006). Environmental Impact Assessment. Volume II of Livestock Production Originated by Agriculture and Consumer Protection.

Federal Research Division, FRD (2005). Country Profile: Ethiopia. Addis Ababa, Ethiopia.

Feyera Senbeta and Demel Teketay (2003). Diversity, community types and population structure of woody plants in Kimphee Forest, a virgin Nature Reserve in Southern Ethiopia. *Ethiop. J. Biol. Sci.*, **2**: 169-187.

Fichtl and Admasu Adi (1994). Honeybee Flora of Ethiopia. Vier-Til rme-Verlag, Benedict Press. Münsters-chwarzach, Germany.

Friis IB. (1992). Forest and Forest Trees of Northeast Tropical Africa: Their natural habitats and distribution pattern in Ethiopia, Djibouti and Somalia. *Kew. Bull. Add. Ser.* **15**: 396

Friis, IB. and Sebsebe Demissew (2001). Vegetation maps of Ethiopia and Eritrea. A review of existing maps and the need for a new map for the flora of Ethiopia and Eritrea. **In:** *Biodiversity Research in the Horn of Africa Region.* pp. 399-439 (Friis, IB. and Ryding, O. eds). Proceedings of the 3rd International symposium on the Flora of Ethiopia and Eritrea at the Carlsberg Academy, Copenhagen.

Genene Bekele (2005). Floristic Composition and Structure of the Vegetation of Magada Forest, Borana zone, Oromia National Regional State. M.Sc. Thesis, Addis Ababa University.

Getachew Tadesse, Tamrat Bekele and Sebsebe Demissew (2005). Floristic analysis and anthropogenic influences on dryland Vegetation of Wello, Ethiopia. **In**: *Biodiversity Research for Livelihood Support and Food Security*, PP. 35-40 (Bernard, K., Meshack, M., Thomas, O. and Paul, O. (eds). Workshop proceedings. National Museum of Kenya.

Gete Zeleke (2010). A Study on Mountain Externalities in Ethiopia. Sustainable Agriculture and Rural Development, Mountain Policy Project. Addis Ababa, Ethiopia.

Goldsmith, F.B, Harrison, C.M. and Morton, A.J. (1986). Description and analysis of vegetation. **In:** *Methods in Plant Ecology*, pp. 437-515, (Moore, P.D. and Chapman, S.B. eds). Blackwell Scientific Publications, Oxford.

Greig-Smith, P. (1983). Quantitative Plant Ecology (3rd edn.). Butterworths, London.

Grytnes, J. A. and Vetaas, O.R. (2002). Species Richness and Altitude: A comparison between Null Models and Interpolated Plant Species Richness along the Himalan AltitudinalGradient, Nepal. *The American Natural*. **159**: 294-304.

Haile Yinger, Ensermu Kelbessa, Tamrat Bekele and Ermias Lulekal (2008). Floristic composition and structure of the dry afromontane Forest at Bale Mountains National Park, Ethiopia*. SINET: Ethiop. J. Sci.*, **31**:103-120.

Homeier, J. (2008). The influence of topography on forest structure and regeneration dynamics in an Ecuadorian montane forest. **In:** *The Tropical Mountain Forest – Patterns and Processes in a Biodiversity Hotspot.* (eds) Gradstein, S.R., Homeier, J. and Gansert, D. Göttingen Centre for Biodiversity and Ecology. *Biodiversity and Ecology Series* 2: 97-107

Huston, M. A. (1994). Biological diversity. The Existence of Species on Changing Landscapes. Cambridge University Press, Cambridge, Pp. 681.

Hutchings, M.J. (1997). The structure of plant populations. In: *Plant Ecology*, (Crawley, M. J. ed). Blackwell Science Lat, London. pp. 325- 358.

IBC (2001). Biodiversity conservation in ancient church and monastery yards in Ethiopia - Addis Ababa: Institute of Biodiversity Conservation and Research Addis Ababa.

IBC (2005). National Biodiversity Strategy and Action Plan. Addis Ababa, Ethiopia.

IBC (2008). Ethiopia: Second Country Report on the state of PGRFA to FAO. Addis Ababa, Ethiopia.

IBC (2009). Convention on Biological Diversity (CBD) Ethiopia's 4th country Report. Addis Ababa, Ethiopia.

IUCN (2001). The Red List of Threatened Species. G. land Switzerland and Cambridge, UK.

Jaccard, P. (1912): The distribution of the flora in the alpine zone. New Phytologist 11(2):37-50.

Jennings, M., Jennings, O., Glenn-Lewin, D., Peet, R., Faber-Langendoen, D., Grossman, D., Damman, G., Barbour, M., Pfister, R., Walker, M., Talbot, S., Walker, J., Hartshorn, G., Waggoner, G., Abrams, M., Hill, A., Roberts, D. and Tart, D. (2003). Guidelines for describing Associations and Alliances of the U.S. National vegetation classification Panel.

Kent, M. and Coker, P. (1992). Vegetation Description and Analysis: A practical approach. Belhaven press, London, 363 p.

Khurana, E. And Singh, J.S. (2001). Ecology of tree seed and seedlings: Implications for tropical forest conservation and restoration. Current Science 80: 748-757.

Kitessa Hundera (2003). Floristic composition and structure of the Adaba-Dodolla forest, Bale zone, Oromia Regional State, Ethiopia (Unpublished). M.Sc thesis, Addis Ababa University, Addis Ababa.

Kotwal, C.P., Kandari, S.L. and Dugar, D. (2008). Bioindicators in sustainable management of tropical forests in India. *Afri. J. Plant Sci.*, **2**:99-104.

Krebs, C.J. (1999). *Ecological Methodology*. Second edition. Addison-Welsey Educational Publishers, U.S.A, p 620.

Kumelachew Yeshitela (1997). An Ecological Study of Afromontane Vegetation of Southwestern Ethiopia. M.Sc. thesis, Addis Ababa University. Addis Ababa.

Lalisa Alemayehu, Hager H, and Gruber, M. (2009). The community-state forest interaction in Menagesha Suba area, Ethiopia: the challenges and possible solutions. For Trees Livelihoods **19**:111–128.

Lightbourne, M. (2006). The legal environment of seed markets in Ethiopia – is coffee faring better outside the FAO multilateral system? Queen Mary Institute.

Lisanework Nigatu and Mesfin Tadesse (1989). An Ecological study of the vegetation of the Harenna forest, Bale, Ethiopia. *SINET. Ethiop. J. Sci.* **12**: 63-93.

Lissanework Nigatu (1987). An Ecological Study of the Vegetation of Harenna Forest. M. Sc. thesis. Addis Ababa University. Addis Ababa.

Lovett, J.C., Rudd, S. and Frimodt-Muler, C. (2000). Patterns of Plant Diversity in Africa, South of Sahara and Their Implication for Conservation Management. *Biodiversity Conserv*. **9**: 37-46.

Magurran, A.E. (1988). Ecological Diversity and its Measurement. Princeton University Press, Inc. London, pp. 385.

Mathenge, Lucy (1995). Nutritional value and utilization of indigenous vegetables in Kenya. **In:** *Proceedings of the international workshop on genetic resources of traditional vegetables in Africa*, Nairobi, Kenya.

McGeoch, A., van Rensburg, B., and Botes, A. (2002). The verification and application of bioindicators, a case study of dung beetles in savannah ecosystem. *J. Applied Eco*. **30**:361-372.

McKee, J. (2007). Ethiopia: Country Environmental Profile. EC Delegation, Addis Ababa, Ethiopia.

MEA (2005). Ecosystems and Human Well-Being: Biodiversity Synthesis. Washington: World Resources Institute / Island Press.

Mengesha, M.H. (1975). Crop germplasm diversity and resources in Ethiopia. **In:** *Crop genetic resources for today and tomorrow.* In: O.H. Frankel and J.G. Hawkes (eds), International Biological Programme Synthesis, Vol 2. Cambridge University Press, Cambridge, London.

MOARD (2002). Menagesha Suba State Forest Pamphlet. Ministry of Agriculture and Rural Development, Addis Ababa, Ethiopia.

Mugabe, J. (1998). Biodiversity and sustainable development in Africa. **In:** *Managing Biodiversity: National Systems of Conservation and Innovation in Africa.* Mugabe, J. and Clark, N. (eds). African Center for Technology Studies (ACTS), Nairobi, Kenya. pp. 5-30.

Muller-Dombois, D. and Ellenberg, H. (1974). Aims and Methods of Vegetation Ecology. Wiley and Sons, New York, 547pp.

Mulugeta Lemenih, (2004). Effects of Land Use Changes on Soil Quality and Native Flora Degradation and Restoration in the Highlands of Ethiopia. Implications for sustainable land management. Doctoral Thesis Swedish University of Agricultural Sciences

Murphy, P. G. and Lugo, A.E. (1986). Ecology of tropical dry forest. *Ann. Rev. Ecol. Syst*. 17: 67-88.

Rademaekers, K., Eichler, L., Berg, J., Obersteiner, M., and Havlik, P. (2010). Study on the Evolution of Some Deforestation Drivers and Their Potential Impacts on the Costs of an Avoiding Deforestation Scheme. European Commission: Final Report.

Richter, M. (2008). Tropical Mountain forests – distribution and general features. **In:** *The Tropical Mountain Forest Patterns and Processes in a Biodiversity Hotspot.* S. Robbert Gradstein, Jürgen Homeier and Dirk Gansert (Eds.) *Biodiversity and Ecology Series*: Volume 2, Universitätsverlag Göttingen, German.

Rojahn, A. (2006). Incentive Mechanisms for A Sustainable Use System of the Montane Rain Forest in Ethiopia. Inaugural-Dissertation, Berlin, Germany.

Rosenzweig, H.C. (1995). Species Diversity in Space and Time. Cambridge University Press.Cambridge.

Roundy, R.W. (1985). Environmental productivity in pre-revolutionary Ethiopia: perennial vegetation resources. *Discussion Paper Series* No. 33. Montreal, Canada, Centre for Developing-Area Studies, McGill University.

Scackelton, C.M. (2000). Comparison of plant diversity in protected area and communal lands in Bushbuck ridge Lower Savannah, South Africa. *Biological Conserve.* **94**: 273-285.

Sebsebe Demissew (1980). *A Study on the Structure of Montane Forest*. The Menagesha State Forest. M. Sc.thesis. Addis Ababa University, Addis Ababa.

Sebsebe Demissew, Mengistu Wondafrash and Yilma Dellegne (1996). Ethiopa's Natural Base.Pp.36-53 in Important Bird Areas of Ethiopia: A First Inventry. Ethiopia Wildlife and Natural History Society, Addis Ababa, Ethiopia.

Shambel Bantiwalu (2010). Floristic composition, structure and regeneration status of plant species in Sanka Meda Forest, Guna District Arsi zone of Oromia Region southeast Ethiopia. M.Sc. Thesis, Addis Ababa University, Addis Ababa.

Shannon, C.E. and Weiner, W. (1949). The Matimatical Theory of Communication. University of Illinois Press, Urbana III.

Shiva, V. (1990). Biodiversity: A Third World Perspective, Third World Network, Pulau Penang, Malaysia.

Siiriäinen, A. (1996). Man and forest in African history. **In:** *Sustainable forestry challenges for developing countries.* Palo, M. and Mery, G. (eds.).. Kluwer Academic Publisher.

Supriya, D. L. and Yadava, P.S. (2006). Floristic diversity assessment and vegetation analysis of tropical semievergreen forest of Manipur, north east India. *International Society for Tropical Ecology*.Tropical Ecology **47**(1): 89-98.

Tadesse Woldemariam (2003). Vegetation of the Yayu Forest in southwest Ethiopia: Impacts of human use and implications for In situ conservation of wild Coffea arabica L. Populations. *Ecology and Development Series* No. 10. Center for Development Research, University of Bonn.

Tamrat Bekele (1993). Vegetation ecology of remnanat afromontane forests of the central plateau of Shewa, Ethiopia. Acta Phytogeographica Suecica 79:1-59.

Tamrat Bekele (1994). *Studies on Remnant Afromontane Forests on Central Plateau of Shewa.* Ph. D. Thesis. Uppsala University, Sweden. **5**(1):87-98.

Teshome Ashine (1990). "Wildlife Conservation." In Proceedings of the Conference on National Conservation Strategy for Ethiopia, 22–25 May 1990, Addis Ababa, Ethiopia, pp. 20–21. Institute of Development Research of Addis Ababa University.

Teshome Soromessa, Demel Teketay & Sebsebe Demissew (2004). Ecological study of the vegetation in Gamo Gofa zone, southern Ethiopia. Addis Ababa, Ethiopia.

UNEP (1983). Ecology and Environment: What Do We Know about Desertification? Desertification Control 3: 29.

USAID)/Ethiopia (2008). United States Agency for International Development (*Ethiopia Biodiversity and Tropical Forests 118/119 Assessment.*

Van der Maarel, E. (1979). Transformation of cover abundance values in phytosociology and its effect on community. *Vegetatio*, **39**: 97-114.

Vivero J.L., Ensermu Kelbessa and Sebsebe Demissew (2004). Red List of Endemic Flowering Plants of Ethiopia and Eritrea, 5th Draft (Unpublished). National Herbarium, Addis Ababa University.

Vivero, J. L., Ensermu Kelbessa and Sebesebe Demissew (2005). The Red list of Endemic Trees and Shrubs of Ethiopia and Eritrea. Fauna and Flora International, Cambridge, UK.

Von Breitenbach, F. (1963). Forests and wood lands of Ethiopia, a geobotanical contribution to the knowledge of the principal plant communities of Ethiopia, with special regard to forestry. *Ethiop. For. Rev*. 1: 5-16.

WBISPP (2004). Digital Land Cover Classification of SW Ethiopia (Woody Biomass Inventory and Strategic Planning Project). *Forest Resources of Ethiopia*. Addis Ababa, Ethiopia.

Westhoff, V. and van der Maarel, E. (1978). The Braun-Blanquet approach. **In**: *Classification of Plant Communities*. pp. 287-399, (Whittaker, R.H., ed.). Junk, The Haugue.

Whittaker, H.G. (1975). Communities and Ecosystem. 2nd edition, Macmillan Publishing Co. Willey and Sons, New York, USA, 547 p. Plateau of Shewa, Ethiopia. Acta Phytogeographica Suecica 79: 1-59.

WWF (2001). Ethiopian Montane Forests. Awash National Park, Ethiopia.

Zerihun Woldu (1999). Forest in the vegetation types of Ethiopia and their status in geographical context. **In:** *Forest Genetic Resources Conservation:* Principles, strategies and Action. Proceeding the National Forest Genetic Resource Conservation strategies Development Workshop, pp.1-8, (Edward, S., Abebe Demisse, Taye Bekele and Haase, G. eds). Institute of Biodiversity Conservation and Research (IBCR), and German Technical cooperation (GTZ), Addis Ababa, Ethiopia.

Zerihun Woldu, Feoli, E and Lisanework Nigatu (1989). Partitioning an elevational gradient of vegetation from southeastern Ethiopia by probabilistic methods. *Vegetatio* **81**:189-198.

Zewdu Eshetu (2000). Forest Soils of Ethiopian Highlands: Their Characteristics in Relation to Site History. Studies Based on Stable Isotopes. Doctoral thesis, Swedish University of Agricultural Sciences, Department of Forest Ecology, Umea.

7. APPENDICES

Appendix 1 List of herbaceous flowering plants from Menagesha Suba State Forest

No	Botanical Name	Vernacular Name	Family	Coll.No
1	*Achyranthes aspera* L.		Amaranthaceae	L01
2	*Agrocharis incognita* Fresen.		Apiaceae	L08
3	*Alchemilla abyssinica* Fresen.		Rosaceae	L43
4	*Alchemilla pedata* A. Rich.		Rosaceae	L44
5	*Alepidia peduncularis* Steud. ex A.Rich.		Apiaceae	L45
6	*Andropogon gayanus* Kunth		Poaceae	L125
7	*Anthericum corymbosum* Baker		Anthericaceae	L126
8	*Argyrolobium confertum* Polhill		Fabaceae	L127
9	*Arisaema enneaphyllum* Hochst. ex A.Rich.		Araceae	L46
10	*Artemisia afra* Jacq.ex Willd		Asteraceae	L85
11	*Asparagus africanus* Lam.		Asparagaceae	L10
12	*Bidens pilosa* L.	*Kelloo*	Asteraceae	L47
13	*Campanula edulis* Forssk.		Campanulaceae	L74
14	*Cardamine africana* L.		Brassicaceae	L48
15	*Carduus leptacanthus* R.E. Fries	*Qoree*	Asteraceae	L11
16	*Carduus schimperi* Sch.Bip. ex A.Rich.	*Qoree*	Asteraceae	L49
17	*Carex spicato-paniculata* Böck. ex C.B. Clarke	*Alaaduu'u*	Cyperaceae	L12

18	*Carum piovanii* Chiov.		Apiaceae	L09
19	*Caylusea abyssinica* (Fresen.) Fisch. & Mey.		Residaceae	L128
20	*Cineraria abyssinica* Sch. Bip. ex A. Rich.		Asteraceae	L87
21	*Commelina africana* Hochest. ex A Rich		Commelinaceae	L51
22	*Convolvulus arvensis* L.	*Kalaalaa*	Convolvulaceae	L15
23	*Convolvulus kilimandschari* Engl.	*Kalaalaa*	Convolvulaceae	L88
24	*Convolvulus sagittatus* Thunb.	*Kalaalaa*	Convolvulaceae	L17
25	*Conyza hypoleuca A.Rich.*		Asteraceae	L111
26	*Conyza integrifolia* (L.f.) O.Kuntze		Asteraceae	L112
27	*Conyza spinosa* Sch.-Bip. ex. Oliv. & Hiern		Asteraceae	L113
28	*Conyza variegata (*L.) Willd		Asterasceae	L114
29	*Crassocephalum macropappum* (Sch. Bip. ex A. Rich.) S. Moore		Asteraceae	L52
30	*Crassula alsinoides* (Hook. F.) Engl.		Crassulaceae	L16
31	*Crepis foetida* L.		Asteraceae	L89
32	*Crepis carbonaria* Sch.Bip.		Asteraceae	L90
33	*Crepis rueppellii* Sch. Bip.		Asteraceae	L115
34	*Cymbopogon commutatus* (Steud.) Stapf		Poaceae	L110
35	*Cynanchum altiscandens* K.Schum		Asclepidaceae	L91
36	*Cynoglossum amplifolium* Hochst.exA.DC		Boraginaceae	L53
37	*Cynoglossum coerulem* Steud. ex DC.		Boraginaceae	L19

38	*Cynoglossum laceolatum* Forssk.		Boraginaceae	L18
39	*Cyperus tenuispica* Steud.		Cyperaceae	L05
40	*Cyperus triceps* Endl.		Cyperaceae	L54
41	*Cyphostemma adenocaule* (Steud.exA.Rich.) Desc.ex Willd & Drummond		Vitaceae	L93
42	*Cyathula cylindrical* Moq.		Amaranthaceae	L14
43	*Dichondra repens* J.R. & G. Forst.		Convolvulaceae	L55
44	*Dichrocephala chrysanthemifolia* (B.L.) DC.		Asteraceae	L56
45	*Drymaria cordata* (L.) Schultes		Caryophyllaceae	L36
46	*Echinops macrochaetus* Fresen.	*Qoree*	Asteraceae	L13
47	*Eragrostis botryodes* W.D. Calyton		Poaceae	L20
48	*Felicia dentata* (A. Rich.) Dandy		Asteraceae	L109
59	*Galium scioanum* chiov.		Rubiaceae	L92
50	*Galium spurium* L.		Rubiaceae	L84
51	*Geranium arabicum* Forssk.		Geraniaceae	L02
52	*Geranium ocellatum* Cambess.		Geraniaceae	L06
53	*Girardinia diversifolia* (Link.) Friis		Urticaceae	L24
54	*Gomphocarpus phillipsiae* (N.E.Br.) Goyder		Asclepiadaceae	L57
55	*Gutenbergia ruepellii* Sch.Bip.		Asteraceae	L108
56	*Haplosciadium abyssinicum* Hochst.		Apiaceae	L58
57	*Helichrysum forskahlii* (J.F. Gmel) Hilliard & Burtt		Asteraceae	L94

58	*Helichrysum glumaceum* D.C		Asteraceae	L116
59	*Helichrysum stenoptrum* DC.		Asteraceae	L95
60	*Holothrix unifolia* (A.Rich.) Rchb. f.		Orchidaceae	L107
61	*Hyparrhenia arrhenobasis* (Hochst. ex Steud.)Stapf		Poaceae	L117
62	*Hyparrhenia cymbaria* (L.) Stapf		Poaceae	L118
63	*Hypericum annulatum* A.Rich.		Hypericaceae	L59
64	*Hypericum peplidifolium* A.Rich.		Hypericaceae	L60
65	*Hypoestes triflora* (Forssk.) Roem.& Schult		Acanthaceae	L03
66	*Impatiens hochstteteri* Warb.		Balsaminaceae	L70
67	*Innula confertiflora* A.Rich.		Asteraceae	L96
68	*Ipomoea crassipes* Hook.f.		Convolvulaceae	L71
69	*Justicia ladanoides* Lam.	*Dargu*	Acanthaceae	L61
70	*Kalanchoe petitiana* A.Rich.	*Bossoqqee*	Crassulaceae	L21
71	*Lagenaria abyssinica* (Hook.f.) C.Jeffrey		Cucurbitaceae	L100
72	*Laggera crispata* (Vahl)Hepper &Wood		Asteraceae	L26
73	*Laggera tomentosa* (Sch.Bip. ex A. Rich.) Oliv. & Hiern		Asteraceae	L22
74	*Leptochloa rupestris* C.B.Hubb.		Poaceae	L04
75	*Lithospermum afromontanum* Wiem.		Boraginaceae	L23
76	*Lobelia giberroa* Hemsl.		Lobeliaceae	L97
77	*Lolium temulentum* L.		Poaceae	L86

78	*Medicago polymorpha* L.		Fabaceae	L72
79	*Mikaniopsis clematoides* (Sch. Bip. ex A. Rich.)Milne-Redh.		Asteraceae	L14
80	*Mimulopsis solmsii* Schweinf.		Acanthaceae	L25
81	*Monopsis stellarioides* (Presl.) Urban		Lobeliaceae	L73
82	*Nigella damascena* L.		Rannunculaceae	L27
83	*Ocimum lamiifolium* Hochst. ex Benth.		Lamiaceae	L75
84	*Orobanche ramosa* L.		Orobanchaceae	L98
85	*Otostegia erlangeri* Benth.		Lamiaceae	L106
86	*Oxalis procumbens* Steud. ex A. Rich.		Oxalidiaceae	L07
87	*Passiflora caerulea* L.		Passifloraceae	L38
88	*Pegolettia senegalensis* Cass.		Asteraceae	L99
89	*Pelargonium whytei* Bak.		Geraniaceae	L03
90	*Pennisetum sephacelatum* (Nees) Th. Dur. & Schinz		Poaceae	L76
91	*Pennisetum setaceum* (Forrsk.) Chiov.		Poaceae	L105
92	*Pentanema indicum* A.Rich.		Asteraceae	L77
93	*Pentatropis nevalis* (J.F. Gmel.) D.V. Field & J.R.I. Wood		Asclepiadaceae	L29
94	*Peperomia abyssinica* Miq.		Piperaceae	L28
95	*Peperomia rotundifolia* (L.) Kunth		Piperaceae	L30
96	*Periploca linearifolia* Quart. Dill. & A. Rich.		Asclepiadaceae	L31

97	*Phaulopsis imbricata* (Forssk) Sweet		Acantaceae	L34
98	*Physalis peruviana* L.		Solanaceae	L29
99	*Picris abyssinica* Sch.Bip.		Asteraceae	L101
100	*Pimpinella oreophila* Hook.f.		Apiaceae	L32
101	*Plantago lanceolata* L.		Plantaginaceae	L33
102	*Plantago palmata* Hook. f.		Plantaginaceae	L37
103	*Plectocephalus varians* (A.Rich.) Jeffery		Asteraceae	L35
104	*Polygala rupicola* A. Rich.		Polygalaceae	L124
105	*Rhoicissus tridentata (L. f.)* Wild & Drummond		Vitaceae	L50
106	*Rubia cordifolia* L.		Rubiaceae	L78
107	*Salvia nilotica* Jacq.		Lamiaceae	L119
108	*Sanicula elata* Buch. Ham. ex D. Don		Apiaceae	L36
109	*Satureja abyssinica* (Benth.) Briq.		Lamiaceae	L79
110	*Satureja paradoxa* (Vatke) Engler Sch. Bip.		Lamiaceae	L102
111	*Scabiosa columbaria* L.		Dipsacaeae	L120
112	*Smilax aspera* L.		Smilacaceae	L39
113	*Solanecio gigas* (Vatke) C. Jeffrey		Asteraceae	L80
114	*Solanium anguivi* Lam.		Solanaceae	L40
115	*Solanium incanum* L.		Solanaceae	L30
116	*Sonchus bipontini* Aschers.		Asteraceae	L121

117	*Sporobolus piliferus* (Trin.) Kunth		Poaceae	L83
118	*Stephania abyssinica* (Dillon & A.Rich.)Walp.		Menispermaceae	L41
119	*Swertia engleri* Gilg		Gentianaceae	L63
120	*Tagetes minuta* L.		Asteraceae	L42
121	*Teramnus labialis* (L.f.) Spreng.		Fabaceae	L122
122	*Thalictrum rhynchocarpum* Dill. & A.Rich.		Rannunculaceae	L81
123	*Thymus schimperi* Ronnign.		Lamiaceae	L104
124	*Trifolium acaule* Steud. ex A. Rich.		Fabaceae	L32
125	*Trifolium simense* Fresen.		Fabaceae	L123
126	*Tripogon leptophyllus (A. Rich) Cuf.*		Poaceae	L103
127	*Triumfetta annua* L.		Tiliaceae	L67
128	*Trochomeria macrocarpa* (Sond.) Hook.f.		Cucurbitaceae	L82

Appendix 2 Location of quadrats/plots in relation to altitude, latitude, longitude, number of species

Transect	Plots	Aspect(AS)	Latitude (E)	Longitude (N)	Altitude (m)	Transect	Plot	Aspect	Latitude (E)	Longitude (N)	Altitude (m)
ONE	1	W	3217.2	5756.7	2450	TWO	38	W	3158.9	5755.2	2467
	2	W	3219.9	5757.4	2477		39	W	3201.7	5759.2	2469
	3	N	3222.3	5759.9	2415		40	W	3203	5801.5	2396
	4	N	3225.8	5800.6	2413		41	W	3205.6	5802.9	2404
	5	W	3229.35	5780.25	2437		42	W	3209.2	5802.9	2414
	6	NW	3232.9	5759.9	2461		43	W	3212.8	5803.3	2424
	7	NW	3236.4	5800.6	2484		44	SE	3219.1	5804	2410
	8	E	3239	5802.2	2504		45	SE	3218.8	5804.4	2422
	9	E	3245.3	5802.1	2512		46	SE	3225.4	5801.7	2424
	10	E	3245.6	5802.4	2548		47	SE	3225.6	5801.8	2434
	11	SE	3245.3	5802.2	2546		48	SE	3228.2	5802.8	2404
	12	SE	3249.3	5802.3	2570		49	SE	3235.8	5805.2	2469
	13	S	3251.3	5801.4	2588		50	SE	3239.4	5805.5	2464
	14	S	3256.2	5802.8	2598		51	SE	3245	5806.1	2457
	15	S	3300.3	5803.6	2612		52	E	3243.6	5807	2472
	16	S	3306.6	5850.7	2624		53	E	3249.5	5808.8	2485
	17	S	3304.8	5807.9	2631		54	SE	3253.2	5809.5	2528
	18	S	3312.6	5809.1	2628		55	SE	3254.9	5811.6	2555
	19	S	3315	5807.6	2660		56	S	3259.4	5811.7	2564
	20	S	3317.4	5807.4	2674		57	S	3302.2	5814.4	2572
	21	S	3319.7	5807.1	2655		58	W	3306	5816	2584
	22	S	3324.1	5805.6	2723		59	W	3308.6	5817.1	2660
	23	S	3327.6	5805.5	2699		60	W	3318.6	5817.5	2663
	24	S	3331.2	5802.8	2701		61	W	3316.5	5817.4	2674
	25	S	3335.1	5800.2	2770		62	W	3319.8	5817.5	2637
	26	S	3337	5800.2	2810		63	W	3321.1	5818.4	2666
	27	S	3341	5800.4	2842	THREE	64	W	3253.7	5753.5	2514
	28	S	3347	5800.2	2863		65	W	3254	5752.2	2564
	29	S	3350.7	5800	2860		66	W	3257.2	5751.9	2574
	30	S	3354.5	5759.4	2855		67	W	3259.6	5750.7	2596
	31	S	3358.1	5759.8	2873		68	E	3304	5755.4	2581
	32	S	3401	5757.8	2875		69	E	3307.9	5754.6	2553
	33	S	3404.6	5759.7	2877		70	E	3311.9	5753.8	2672
	34	S	3406.3	5801.9	2890		71	E	3315.8	5755.8	2650
	35	S	3410.9	5801.9	2896		72	E	3319.2	5755.2	2667
	36	S	3411.7	5804.3	2910		73	E	3323.5	5755.2	2763

Appendix 3 Synoptic table for herbaceous flowering plant species diversity of Menagesha Suba State Forest

Summary of 75 plots of with 106 species number										
No.	Name	Mean	Stand.Dev.	Sum	Minimum	Maximum	S	E	H	D`
1	Plot1	5.349	43.32	567	0	444	8	0.434	0.902	0.3776
2	Plot2	3.896	28.263	413	0	288	9	0.547	1.201	0.4988
3	Plot3	3.991	27.974	423	0	284	9	0.574	1.262	0.5313
4	Plot4	4.358	16.826	462	0	120	16	0.804	2.231	0.8513
5	Plot5	1.877	15.923	199	0	163	5	0.43	0.693	0.3183
6	Plot6	2.349	12.91	249	0	117	8	0.72	1.497	0.7083
7	Plot7	3.075	14.818	326	0	133	13	0.727	1.864	0.7736
8	Plot8	2.953	13.606	313	0	100	9	0.79	1.737	0.7921
9	Plot9	5.349	32.416	567	0	319	14	0.594	1.569	0.6474
10	Plot10	3.075	21.407	326	0	218	11	0.554	1.329	0.5378
11	Plot11	3.274	16.86	347	0	165	18	0.679	1.962	0.7427
12	Plot12	4.594	22.941	487	0	203	17	0.677	1.917	0.7576
13	Plot13	5.066	28.219	537	0	266	16	0.625	1.733	0.7006
14	Plot14	6.321	42.754	670	0	436	19	0.514	1.512	0.563
15	Plot15	3.991	16.99	423	0	121	17	0.742	2.103	0.8212
16	Plot16	4.755	22.239	504	0	210	21	0.704	2.143	0.7861
17	Plot17	7.943	40.936	842	0	373	22	0.612	1.892	0.7424
18	Plot18	3.962	21.495	420	0	187	15	0.601	1.628	0.7156
19	Plot19	5.349	27.186	567	0	270	20	0.684	2.05	0.7492
20	Plot20	6.943	38.659	736	0	377	21	0.609	1.854	0.7009
21	Plot21	7.057	33.904	748	0	315	26	0.641	2.09	0.7748
22	Plot22	7.425	45.858	787	0	468	28	0.555	1.848	0.6341
23	Plot23	4.189	14.705	444	0	128	33	0.758	2.65	0.8754
24	Plot24	5.67	22.918	601	0	200	34	0.679	2.396	0.8379
25	Plot25	6.821	27.594	723	0	263	33	0.718	2.51	0.8376
26	Plot26	6.057	22.551	642	0	178	33	0.736	2.572	0.861
27	Plot27	4.66	11.679	494	0	78	34	0.86	3.031	0.9319
28	Plot28	3.255	12.678	345	0	88	20	0.762	2.282	0.8488
29	Plot29	2.491	9.11	264	0	86	27	0.801	2.64	0.8655
30	Plot30	7.142	30.311	757	0	254	29	0.667	2.245	0.8222
31	Plot31	4.472	16.94	474	0	147	26	0.765	2.494	0.8565
32	Plot32	2.925	9.473	310	0	79	26	0.823	2.681	0.8925
33	Plot33	2.877	8.249	305	0	52	25	0.87	2.802	0.9138
34	Plot34	6.189	19.582	656	0	124	28	0.779	2.596	0.897
35	Plot35	7.368	55.489	781	0	570	21	0.426	1.297	0.4605
36	Plot36	4.377	16.603	464	0	120	24	0.756	2.404	0.8561

37	Plot37	4.557	14.842	483	0	92	21	0.819	2.492	0.8914
38	Plot38	5.519	20.54	585	0	175	22	0.77	2.38	0.8611
39	Plot39	5.208	17.568	552	0	147	26	0.788	2.568	0.8842
40	Plot40	4.849	20.624	514	0	193	25	0.727	2.339	0.8215
41	Plot41	3.453	12.213	366	0	97	20	0.821	2.46	0.8736
42	Plot42	2.349	14.28	249	0	144	17	0.597	1.691	0.6452
43	Plot43	4.991	18.072	529	0	134	23	0.777	2.435	0.868
44	Plot44	3.189	17.577	338	0	143	15	0.613	1.66	0.7066
45	Plot45	6.774	35.014	718	0	328	24	0.619	1.968	0.7409
46	Plot46	2.094	6.427	222	0	46	18	0.886	2.56	0.9026
47	Plot47	2.151	7.483	228	0	51	18	0.815	2.357	0.8775
48	Plot48	5.642	21.023	598	0	156	20	0.763	2.287	0.8608
49	Plot49	7.934	32.375	841	0	264	22	0.717	2.217	0.835
50	Plot50	6.094	30.183	646	0	257	16	0.672	1.864	0.7613
51	Plot51	4.321	13.432	458	0	83	25	0.815	2.622	0.9002
52	Plot52	6.066	18.523	643	0	105	25	0.818	2.632	0.9034
53	Plot53	5.802	22.372	615	0	208	24	0.778	2.472	0.8516
54	Plot54	4.472	14.34	474	0	88	24	0.815	2.59	0.8945
55	Plot55	4.528	17.484	480	0	162	25	0.768	2.473	0.8513
56	Plot56	5.632	24.537	597	0	239	28	0.719	2.396	0.8132
57	Plot57	6.783	39.046	719	0	391	22	0.599	1.851	0.6809
58	Plot58	6.443	33.985	683	0	342	25	0.651	2.096	0.7306
59	Plot59	4.104	13.51	435	0	82	17	0.846	2.398	0.8893
60	Plot60	4.491	19.199	476	0	185	25	0.732	2.357	0.8198
61	Plot61	9.651	40.513	1023	0	298	28	0.698	2.326	0.8259
62	Plot62	4.245	11.92	450	0	92	30	0.841	2.861	0.9169
63	Plot63	5.425	14.859	575	0	79	34	0.817	2.881	0.9205
64	Plot64	4.755	16.666	504	0	135	30	0.749	2.549	0.8757
65	Plot65	3.311	10.517	351	0	84	27	0.812	2.676	0.8963
66	Plot66	4.057	19.683	430	0	192	22	0.682	2.108	0.7706
67	Plot67	2.802	11.574	297	0	87	19	0.724	2.133	0.8311
68	Plot68	5.406	26.588	573	0	240	18	0.679	1.964	0.7645
69	Plot69	6.264	45.018	664	0	462	21	0.467	1.422	0.5079
70	Plot70	7.358	36.062	780	0	362	28	0.679	2.261	0.7661
71	Plot71	9.198	56.664	975	0	575	32	0.524	1.815	0.6359
72	Plot72	6.189	31.509	656	0	311	28	0.628	2.094	0.7483
73	Plot73	4.311	13.267	457	0	98	27	0.829	2.731	0.9021
74	Plot74	4.179	18.522	443	0	178	31	0.68	2.335	0.807
75	Plot75	8.519	31.644	903	0	259	35	0.699	2.485	0.8616
	Averages:	4.994	23.11	529.4	0	206.8	22.3	0.702	2.152	0.7784

DEDICATION

This thesis is dedicated to both my beloved brothers Gamachu Etefa and Abebe Haffa whom I lost in 1985 and 1998 respectively. The former brother had left me and his family earlier at his younger age only two months earlier before I started school in 1986 and the later one is older than me whose perception is highly wise and intelligent in nature. It was from him that I learned how to withstand every challenge and obstacles patiently and how to learn from the past events in order to make life easy and meaningful through his strong ideology that education is the ultimate solution to reach the final goal of one's vision.

No farewell words were spoken, no time to say goodbye and no chance to save, you were once gone before I knew it and only God knows why. Therefore, the only things that I can do at this moment are just praying to the almighty God to grant eternal peace and rest to the soul of my departed brothers in the name of the lord Jesus. Having lost you, I never complain /blame God because the truth I know is just without the willingness of Jesus nothing can happen on me and what he has preferred is always in favor of me.

Declaration

I, the undersigned, declare that this thesis is my original work, it has not been presented in other Universities, colleges or institutions, seeking for similar degree or other purposes. All sources of the materials used in the thesis have been duly acknowledged.

Lema Etefa

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Signature Date

This work has been done under the supervision of:

Prof. Ensermu Kelbessa

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Signature Date